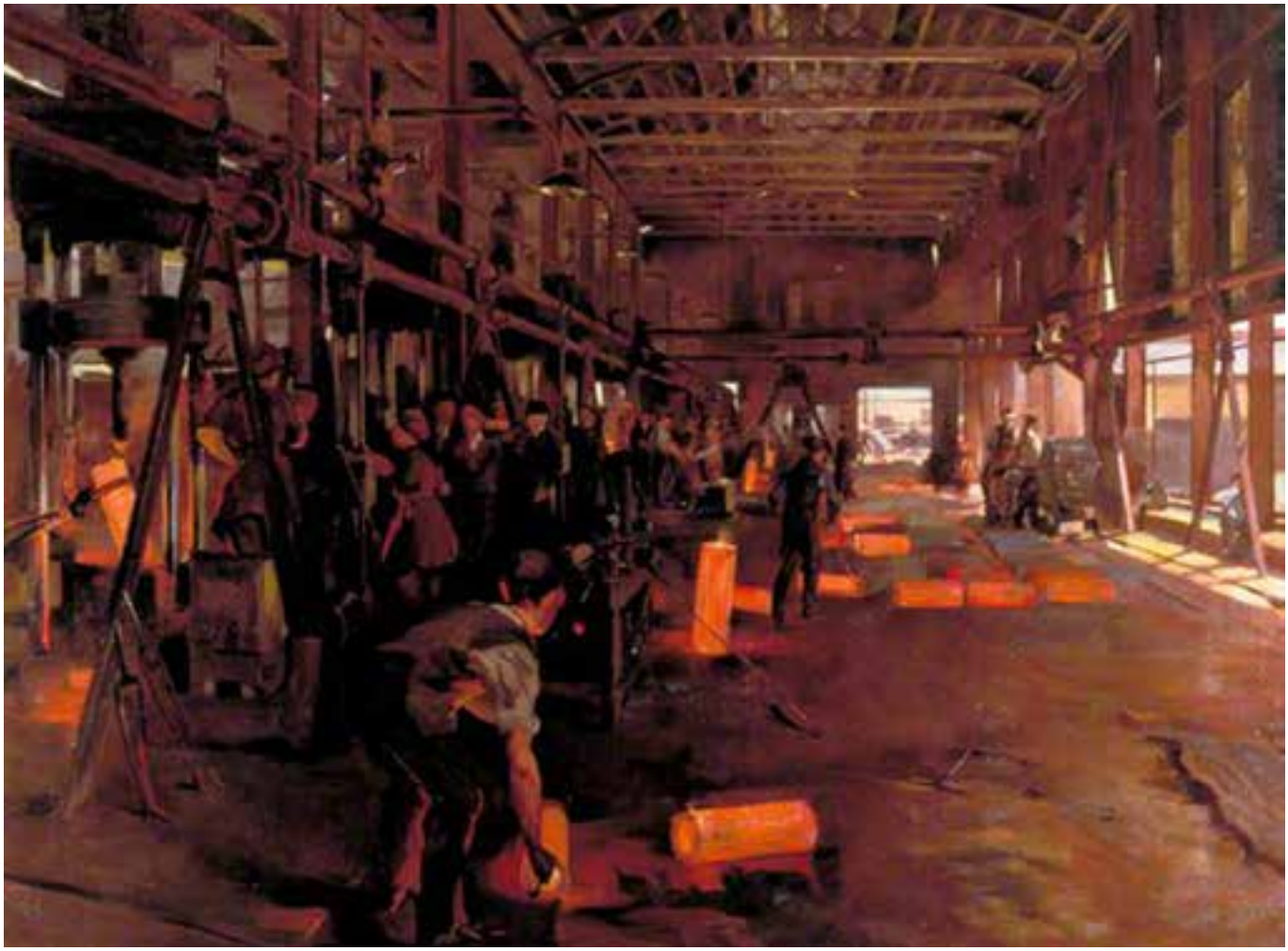
Historic England

Assessment

First World War National Factories: An archaeological, architectural and historical review

David Kenyon

Discovery, Innovation and Science in the Historic Environment



Research Report Series no. 76-2015

Research Report Series 076-2015

First World War National Factories:

An archaeological, architectural and historical review

David Kenyon

© Historic England

ISSN 2059-4453 (Online)

The Research Report Series incorporates reports by the expert teams within the Investigation & Analysis Department of the Research Group of Historic England, alongside contributions from other parts of the organisation. It replaces the former Centre for Archaeology Reports Series, the Archaeological Investigation Report Series, the Architectural Investigation Report Series, and the Research Department Report Series.

Many of the Research Reports are of an interim nature and serve to make available the results of specialist investigations in advance of full publication. They are not usually subject to external refereeing, and their conclusions may sometimes have to be modified in the light of information not available at the time of the investigation. Where no final project report is available, readers must consult the author before citing these reports in any publication. Opinions expressed in Research Reports are those of the author(s) and are not necessarily those of Historic England.

For more information contact Res.reports@HistoricEngland.org.uk
or in writing to:
Historic England, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth PO4 9LD

SUMMARY
This project was designed to improve our understanding of First World War National Factories. These factories were directly controlled by the Ministry of Munitions to produce vital war material, everything from wooden boxes, respirators, shells, and explosives to optical glass and vehicle radiators. Many were adapted from existing works, while others were located in specially designed factories. Some were finished to high architectural standards and followed the latest thinking in factory design and the provision of welfare facilities. In some instances associated housing was included. This report will discuss the historic context of the National Factories, the types of factories created, their layouts and architectural form. It will also explore their social history, including evidence for the organisation of work, welfare provision and, briefly, associated housing. It will also document each factory and produce short desk-based assessments of the extant factories. These may be used to recommend better levels of protection, raise public awareness, enhance management information, and identify any significant and undesignated sites as well as knowledge and protection gaps.

CONTRIBUTORS
The report was researched and compiled by David Kenyon with assistance from Wayne Cocroft. The illustrations were prepared by Trevor Pearson and Philip Sinton. The report was edited by Wayne Cocroft and Kathryn Morrison and desk top published by Jo Bradley.

ACKNOWLEDGEMENTS
Louise Ennis of the Council for British Archaeology provided valuable assistance in locating several factories.
Dale Johnston of Banbury Museum provided information and a tour of Banbury National Filling Factory site.
The assistance of staff at the National Archives, Kew, and the Library of Cambridge University Department of Architecture is also acknowledged.
Help and information was also received from Michael Bellamy, Katie Carmichael, Martin Jeffs, and John Minnis at Historic England.

ARCHIVE LOCATION
Historic England Archive, The Engine House, Fire Fly Avenue, Swindon, SN2 2GZ

DATE OF RESEARCH
April 2014-February 2015

CONTACT DETAILS
Historic England,
24 Brooklands Avenue,
Cambridge,
CB2 2BU.

Wayne Cocroft 01223 582700; Wayne.Cocroft@HistoricEngland.org.uk

© HISTORIC ENGLAND

CONTENTS

LIST OF FIGURES 1

1. INTRODUCTION 6

Background and Scope 6

Aims and objectives 7

Methodology and Sources 8

2. HISTORICAL CONTEXT TO THE ESTABLISHMENT OF THE NATIONAL FACTORIES 9

Background 9

Definitions 12

3. FACTORY DESIGN AND BUILDING TYPES 13

Construction, building materials 13

Production flow 17

Architects and architectural adornment 18

Power supply 19

Transport 21

Welfare provision 25

Housing schemes 31

4.1 ROYAL ORDNANCE FACTORIES (ROF) 36

Purpose 36

Factory Characteristics 36

4.2 HM EXPLOSIVES FACTORIES (HMEF) 42

Purpose 42

Factory Characteristics 47

4.3 NATIONAL SHELL AND NATIONAL PROJECTILE FACTORIES (NSF AND NPF) 56

Purpose 56

Factory Characteristics 57

4.4 NATIONAL FILLING FACTORIES (NFF) 67

Purpose 67

Factory Characteristics 70

4.5 GOVERNMENT FACTORIES FOR CARTRIDGES AND SMALL ARMS AMMUNITION 84

Purpose 84

Factory Characteristics 85

4.6 NATIONAL FACTORIES FOR AIRCRAFT PRODUCTION 90

Purpose 90

Factory Characteristics 91

4.7 CHEMICAL AND ANTI-GAS FACTORIES 97

Purpose 97

Factory Characteristics 98

4.8 MISCELLANEOUS NATIONAL FACTORIES 100

Purpose 100

Factory Characteristics 100

5. SITE SURVIVAL 106

Pre-1914 munitions buildings 106

Pre-1914 buildings adopted as National Factories 106

1914-18 Purpose-built structures 107

Housing 107

Earthworks and other remains 108

ENDNOTES 111

6. BIBLIOGRAPHY 120

Archival Sources 120

Published Sources 121

Online Resources 123

APPENDIX A

LIST OF NATIONAL FACTORIES 125

Map showing National Factories in England 127

Map showing concentration of National Factories in the London area 128

Map showing concentration of National Factories near Manchester, Sheffield, Leeds and Liverpool 129

List of National Factories 130

APPENDIX B
DESK-BASED ASSESSMENTS OF SURVIVING FACTORIES 173

List of sites with surviving structures 173

LIST OF FIGURES

Cover — Shell forging at NPF Hackney Marshes, by Anna Airy 1918 (© IWM Art.IWM ART 4032).

Fig. 2.1 — Lloyd George 'Delivering the Goods', *Punch* cartoon of 21 April 1915 (reproduced in Lloyd George, D, 1938, *War Memoirs of David Lloyd George* (Odhams, London) p. 118).

Fig. 3.1 — NPF Sheffield (Templeborough) machining shop under construction, 24th November 1915 (TNA MUN5/157).

Fig. 3.2 — NFF Hereford, shell store with a north light roof and a complex pattern of runner beams for overhead cranes (M Bellamy).

Fig. 3.3 — NPF Birtley, surviving Belfast Truss roof in the former canteen building (W Cocroft).

Fig. 3.4 — NFF Hereford, design by Sir Frank Baines for an office block (reproduced in *The Builder* 21 March 1919).

Fig. 3.5 — NMGF. Burton on Trent, elevation drawing of office buildings (© Historic England MD95/09210).

Fig. 3.6 — NPF Dudley, No.1 Machine Shop showing shafts and belts for driving machines (© Historic England BB88/07423).

Fig. 3.7 — NPF Birtley, surviving electricity sub-station (W Cocroft).

Fig. 3.8 — NFF Banbury, aerial photograph showing earthworks associated with former railway lines (© Historic England 277884/040).

Fig. 3.9 — NFF Chilwell, workers awaiting the 5.08pm train at Attenborough station, 5 August 1918 (© Historic England AA96/03573).

Fig 3.10 — NFF Banbury, diagrammatic representation of shell filling process (redrawn from TNA MUN5/155/1122.3/51).

Fig. 3.11 — RGPF Waltham Abbey, womens' hospital (now demolished) (© Historic England BB92/26040).

Fig. 3.12 — NSF Liverpool (Cunard), canteen 30 September 1917 (© Historic England BL24001/032).

Fig. 3.13 — Royal Arsenal, Woolwich, workers housing: angled corner block on Prince Rupert Road, Well Hall Estate (© Historic England BB96/227).

Fig. 3.14 — HMEF Gretna; drawing of sample housing block (reproduced in

Building News No. 3226, 2 October 1918, p. 233).

Fig. 3.15 HMEF Queen's Ferry, workers' housing at Mancot Royal, designed by Raymond Unwin (W Cocroft).

Fig 3.16 NPF Birtley; a street in Elizabethville (TNA MUN 5/157).

Fig. 4.1 Royal Arsenal, Woolwich, women moving between danger buildings, 1918 (© IWM Q 27874).

Fig. 4.2 RSAF Enfield, part of the Victorian factory shortly after closure in the 1990s (W Cocroft).

Fig. 4.3 RGPF Waltham Abbey, surviving First World War period buildings constructed to increase cordite output (from 1917 site plan held in RGM Archives).

Fig. 4.4 RGPF Waltham Abbey, surviving cordite incorporation buildings constructed during the 1914-1918 period. (© Historic England BB92/26176).

Fig. 4.5 HMEF Gretna, site plan showing various production areas (redrawn from TNA SUPPLY10/15).

Fig. 4.6 HMEF Gretna, Quinan guncotton drying stoves (W Cocroft).

Fig. 4.7 HMEF Gretna, surviving Magazine buildings at Smalmstown, top right (OS 1:25,000 map).

Fig. 4.8 HMEF Swindon (Stratton works), air photograph, 1920 (© Historic England EPW000941).

Fig. 4.9 HMEF Sutton Oak, undated (possibly Second World War) photograph of factory (© IWM HU 102403).

Fig. 4.10 HMEF Avonmouth air photographed 1927 (© Historic England EPW019264).

Fig. 4.11 HMEF Avonmouth, former office building (© Historic England BB97/117).

Fig. 4.12 NSF Liverpool (Haymarket), the crowded interior of the machine shop installed in the former covered produce market at 1916 (Liverpool Libraries http://merseyside-at-war.org/memorabilia/munitions-factory-in-north-haymarket-liverpool/ accessed 14/10/2014).

Fig. 4.13 NSF Liverpool (Cunard), women workers in Rimrose Road turning

large calibre (8-inch) shells 1917 (© Historic England BL/24001/09).

Fig. 4.14 NPF Sheffield (Tinsley), shell forge at work. The furnaces can be seen to the rear left, with presses in the foreground. Both steel billets and finished shell blanks are stacked nearby (TNA MUN5/157).

Fig. 4.15 NPF Sheffield (Templeborough), plan of the shell-turning shop. Steam wagons entered lower left, and production flow was from bottom to top of the plan with finished shells leaving by rail top left (redrawn from TNA MUN5/157).

Fig. 4.16 NPF Sheffield (Templeborough), interior showing shell-turning bays in operation (TNA MUN5/157).

Fig. 4.17 NPF Birtley, plan, 1918 (redrawn from TNA MUN5/157).

Fig. 4.18 NPF Hackney Marshes, shell forging in a painting by Anna Airy, 1918 (© IWM Art.IWM ART 4032).

Fig. 4.19 NFF No. 5 Quedgeley, plan (redrawn from OS map of 1923, © Historic England).

Fig. 4.20 NFF No. 5 Quedgeley under construction 1915. View looking north along the centre axis of the site with component stores to the left and assembly huts on the right (TNA MUN5/157).

Fig. 4.21 NFF No. 1 Leeds (Barnbow). Interior view showing 18pdr assembly (undated). Note the single-storey wooden hut, Belfast Truss roof, and lack of blast protection (TNA MUN5/157).

Fig. 4.22 Plan of NFF No. 9 Banbury (redrawn from OS map of 1922, © Historic England).

Fig. 4.23 NFF No 9 Banbury, plan showing un-bunded empty shell stores (left) and paint shops (top), bunded melt and filling houses (centre), and filled-shell stores (right) bunded on three sides (redrawn from O.S. map 1:2,200 Northamptonshire 1922).

Fig 4.24 NFF No. 14 Hereford, surviving picric acid expense store (W Cocroft).

Fig. 4.25 NFF No. 1 Leeds (Barnbow), Amatol Section showing the melting, incorporating and pressing houses for this explosive (West Yorkshire Archive Service, Leeds WYL115/MA/6).

Fig. 4.26 NFF No. 6 Chilwell. View taken on 17th May 1916, looking south. The ammonium nitrate mill is on the centre left, with the TNT mill next right, then the mixing house. Covered conveyor belts carry the mixed amatol to the press houses located behind the camera position (©

Historic England AA96/03602).

Fig. 4.27 NFF No. 6 Chilwell, the interior of the shell store. (© Historic England AA96-03350).

Fig. 4.28 NFF No. 7 Hayes, showing layout of huts and clean-ways (TNA MUN5/154).

Fig. 4.29 TWFF Walthamstow. Lachrymatory grenade filling. Note the youth of several of the employees (TNA MUN5/368).

Fig. 4.30 Chemical Shell Assembling Station Greenford, plan (redrawn from Wootton and Lowry 1919).

Fig. 4.31 NFF (Chemical) Chittening, air photograph of factory, 1927 (© Historic England EPW019258).

Fig. 4.32 Royal Arsenal, Woolwich, Small Arms Factory 3, women workers finishing small arms ammunition, May 1918 (© IWM Q 27880).

Fig. 4.33 GCF No.4 Edmonton, air photograph of factory, 1933 (© Historic England EPW042088).

Fig. 4.34 GCF No.1 Blackheath (Birmingham) air photograph, 1924 (© Historic England EPW010510).

Fig. 4.35 Government Rolling Mills, Southampton. Plan (redrawn from *The Engineer* 1919).

Fig. 4.36 RAE Farnborough, the original post 1905 balloon factory (now demolished), 1995 (© Historic England BB98/26770).

Fig. 4.37 NAF No.3 Aintree, air photograph, 1928 (© Historic England EPW020354).

Fig. 4.38 NAF No.2 Heaton Chapel interior in 1918, showing DH9 aircraft under assembly (http ://en.wikipedia.org/wiki/National_Aircraft _Factory_No._2 #mediaviewer/File:NAF_No.2_1918.jpg, accessed 04/11/2014).

Fig. 4.39 National Aero-Engine Factory Ladbroke Grove (© Historic England DP096483).

Fig. 4.40 National Balloon Factory Finchley, the interior of the Bohemia Picture Palace in use for balloon manufacture, date unknown (Friern Barnet & District Local History Society).

Fig. 4.41 National Radiator Factory Greet, the Motor Radiator Manufacturing

Co. works at Greet, Birmingham (later Serck Radiator Co.) air photograph 1935 (© Historic England EPW048061).

Fig. 4.42 CWF Middlewich; interior showing generator (*The Engineer* December 1915).

Fig. 4.43 National Ball-Bearing Factory Chelmsford, formerly Hoffman's, air photograph, 1923 (© Historic England EPW009600).

Fig. 4.44 Mine Sinker Assembly Station Cowley, housed in the W R Morris works, air photograph, 1930 (© Historic England EPW031331).

Fig. 4.45 National Machine Gun Factory Branston (Burton on Trent), air photograph 1927, showing the three storey office complex (centre) and canteen (lower right) (© Historic England EPW019682).

Fig. 5.1 NFF Banbury, former timber-framed factory building in use as coffin store (R Kinchin-Smith).

1. INTRODUCTION

Background and Scope

The First World War National Factories project was undertaken between April 2014 and February 2015. The project was designed to improve understanding of First World War National Factories. These factories were directly controlled by the Ministry of Munitions to produce vital war material, as opposed to the many factories operated independently by private companies to fulfil government contracts. Many of the National Factories were adapted from existing works, while others were located in specially designed factories. These latter, purpose-built sites formed a particular focus of the project. Some were finished to high architectural standards and followed the latest thinking in factory design and the provision of welfare facilities. In some instances associated housing was also constructed and this, too, has been briefly examined.

During discussions to frame the National Heritage Protection Plan (NHPP) it was recognised that many classes of sites and buildings constructed during the First World War were poorly documented and relatively few protected. In anticipation of the centennial commemorations resources were allocated to begin data audits and National Record of the Historic Environment (NRHE) record enhancements of a limited number of First World War monument classes. Among the range of potential sites, factories of the Ministry of Munitions were identified as being a monument type that both held significance and of which there was a very limited and incomplete representation in the English Heritage/Historic England corporate datasets. In 2013 the Heritage Data team created or enhanced 93 records relating to National Factories. Due to unclear addresses around 77 factories remained un-located.

To date the archaeological interest in the First World War in the United Kingdom and abroad has concentrated on the fighting fronts and training for war. This project was intended to contribute to a greater understanding of the impact of total war on the Home Front and its effect on the built environment. The industrial archaeology of 20th century factory design is also a relatively under-studied topic. This project, in addition to providing an increased understanding of munitions manufacture during the First World War, was also intended to provide a snapshot of early 20th century factory design and working conditions.

Prior to the project, elements constructed during the war at three National Factories had been designated. At Branston, Burton-on-Trent the principal buildings of the National Machine Gun Factory are listed at Grade II (1246225). At the National Filling Factory Hereford (Rotherwas) is a Grade II listed Picric Acid Store (1393937). The earthwork remains of the northern section of the National Filling Factory Banbury are also scheduled (1409811).

In addition three historic Royal Ordnance Factories, the Royal Arsenal, Woolwich, the Royal Gunpowder Factory Waltham Abbey, and the Royal Small Arms Factory Enfield, as well as the Royal Aircraft Establishment Farnborough, have been studied

in detail and elements at each are protected by listing and scheduling. Having been studied previously, these sites have been subject to less detailed examination during this project, but are included in the various gazetteers and appendices.

The Royal Naval Cordite Factory, Holton Heath, Dorset, built c.1914, was administered separately by the Admiralty and within it are a number of listed buildings (1382118, 1382125, and 1382128). The remains of a solvent fermentation plant are also scheduled (10109151). A First World War extension to the private Chilworth Gunpowder Works, Surrey, is also included in the scheduled area at that site (1018507). These, too, fell outside the scope of this project

Given the significance of munitions production to the outcome of the war, the societal changes represented by the widespread employment of women in traditional male roles, and advances in industrial production techniques, munitions factories are poorly protected. This project was designed to identify any significant and undesignated sites as well as knowledge and protection gaps.

Aims and objectives

Over 8,700 companies and factories in the UK produced munitions of various sorts during the Great War.[1] However of these only 218 were directly administered by the Ministry of Munitions as National Factories.[2] Of these, 170 National Factories were established in England, at 174 locations, with the balance located in Scotland, Wales and Ireland. The aims of this project were:

1. To identify the locations of the 170 First World War National Factories in England and to assess their survival and condition.

2. Through publication of the report, and enhancement of the NRHE database, to provide local partners with improved information on the location and survival of National Factories to enable them to identify sites for local protection and to deliver management advice.

3. To characterise the types of activities undertaken in the National Factories and to discuss how this is reflected in location and factory design, including:

    i) To understand the geographic distribution of the industry and how it might be influenced by existing regional areas of expertise and labour supply.

    ii) To understand the types of factories required for the manufacture of different types of war material.

    iii) To understand the design and construction process. Do we know who were the architects and engineers responsible for designing the factories? Who built them? What materials were used in their construction? Do these reflect wartime shortages and the need for the speed of construction?

iv) To understand how tightly factory designs reflected manufacturing flow lines? Were they conceived with sufficient flexibility to adapt to changing demands?

v) To understand how improved welfare conditions were represented in factory layouts and, briefly, to discuss associated housing schemes.

4. To recommend better levels of protection; to identify any significant and undesignated sites that may be worthy of further assessment for national or local designation.

5. To improve understanding and awareness of the significance of First World War National Factories.

Methodology and Sources

This report was compiled largely from documentary sources. The primary source for the subject is the official *History of the Ministry of Munitions*, published in 12 volumes between 1920 and 1922 by HMSO The scope of the project was defined with reference to the list of National Factories contained within volume VIII of this work. In addition material was obtained from other published and archival sources, including in particular:

- Contemporary journals for the years c.1914-1920, including *The Builder*, *Buildings News*, *The Engineer*, and other relevant trade and professional publications.
- Archival research at The National Archives and Imperial War Museum.
- Assessment of existing data on NRHE, and selected HERs.
- Examination of online sources, including Historic England's own contemporary and historic map collection, Google Earth and Streetview.
- Examination of aerial photography from a variety of sources including the Aerofilms *Britain From Above* image collection.

Where good survival of physical fabric of the factories was identified, a limited number of sites were visited to carry out additional fieldwork and investigation, in particular photography of surviving structures.

Information on the location and condition of the 174 factories included in the study was compiled and is summarised in Appendix A. Where evidence of surviving fabric was identified, brief desk-based assessments were undertaken of each surviving structure and the results of these are summarised in the Gazetteer included as Appendix B.

2. HISTORICAL CONTEXT TO THE ESTABLISHMENT OF THE NATIONAL FACTORIES

Background

Prior to August 1914 the capacity for munitions production within the UK was relatively small. Only three state-controlled factories were in operation: the Royal Gunpowder Factory (RGPF) at Waltham Abbey, which produced about one third of the cordite propellant required annually by the Army and Navy; the Royal Small Arms Factory (RSAF) at Enfield Lock, which produced rifles and machine guns as well as other small arms; and the complex of Royal Ordnance Factories (ROF) at Woolwich which carried out both manufacture of weapons and assembly and filling of ammunition. Even the peacetime requirements of the armed services were not met by the output of these plants, and much additional *materiel* was acquired through contracts with private firms. These contracts tended to be concentrated with a few trusted companies such as Vickers Armstrong and Cammell-Laird. Also, much of what little defence spending occurred was focused on the Royal Navy, as the nation's principal defence, with the Army coming a poor second. As a consequence the British Expeditionary Force (BEF) which travelled to France in 1914 was not only small in size, consisting of only seven Divisions, but also had limited supplies of war *materiel*. The reserve stockpile of artillery ammunition consisted of 29 million shells: enough, the War Office calculated, for a short war of four major battles.[3]

Shortly after the outbreak of war on 8 August 1914 the first of the Defence of the Realm Acts (DORA) was passed. The powers granted to the Government under these acts included the power to acquire land, and to control a range of resources necessary to the war effort.[4] The existing administrative structures, however, were completely overwhelmed by the scale of the problem and expansion of production was slow. There was also reluctance within Asquith's Liberal government to indulge in what it considered drastic interference in national life through worker registration schemes or other authoritarian measures. The preferred route was simply to offer out contracts to existing suppliers, and let the industry organise itself privately to meet the contracts.[5] Organisation of these contracts was left to the War Office headed by Lord Kitchener, and in particular to his Master General of the Ordnance, Stanley Von Donop. The private sector proved itself incapable of gearing up to meet the new contracts. There was a substantial increase in production. Overall output was up 388% by March 1915, but this was from such a low base that it did not meet the demands of the conflict. Industry was also hampered by labour difficulties including a shortage of workers as a result of the large numbers of men enlisting in the Army.[6] By the spring of 1915 only half the orders for sub-6 inch calibre shells had been fulfilled, and only a third of larger calibres.

The consequence of this was what is popularly known as the 'Shell Scandal' of May 1915. On 14 May *The Times* newspaper published an editorial, and an associated 'Dispatch' from its correspondent in France, Charles à-Court Repington concerning the recent battle at Aubers Ridge which had begun on 9 May. In it he commented that 'the want of an unlimited supply of high explosive was a fatal bar to our success'.[7] It is a widespread myth that this article led to such an outcry that Asquith's

government collapsed and he was forced into coalition. In fact the public and parliamentary debate over munitions production had been on-going since at least March 1915 and other factors were at work in what was more of a cabinet re-shuffle, admitting Unionists to Ministerial posts. Asquith remained Prime Minister until December 1916.

Fig 2.1. Lloyd George 'Delivering the Goods', Punch cartoon of 21 April 1915 (reproduced in Lloyd George, D, 1938 War Memoirs of David Lloyd George *(Odhams, London) p. 118).*

A key outcome, however, was the passage of the 1915 Munitions of War Act, which amongst other measures led to the creation of the Ministry of Munitions and the appointment of David Lloyd George at its head as Minister (Fig 2.1). Lloyd George co-opted a large number of senior figures from outside government, from the business community, to manage the various branches of the new Ministry. He was later to present the result as a well-oiled machine run by 'men of push and go',[8] but in fact the rapid expansion of this new department led to a degree of disorganisation and chaos. When Winston Churchill took over as Minister in 1917 he found that:

> The Growth of the Ministry of Munitions had far outstripped its organisation. [...] I found a staff of 12,000 officials organised in no

> less than fifty principal departments each claiming direct access to the Chief, and requiring a swift flow of decisions upon the most intricate and interrelated problems.[9]

Nonetheless, for all its *ad hoc* nature the Ministry was able to manage the supply of war *materiel* from 1915 until the end of the war.

The Act gave the government far reaching powers to intervene in the workings of the munitions industry. Factories involved could be designated 'Controlled Factories' and the employees therein subjected to a variety of stringent regulations, including the prevention of strikes and lock-outs, and the prevention of re-employment of persons who had resigned from munitions work unless formally approved by their former employer.[10]

In addition the Ministry had the power to create 'National Factories'. These typically came about via one of three routes. In the first instance, on the initiative of Lord Kitchener at the War Office, committees of factory owners and other prominent citizens formed in many of the industrial cities around the country with the intent of assisting the war effort. These committees were assisted with state funding and other resources to create factories of various types in their areas. This was particularly the case with the engineering industry, creating shell-turning factories (see Section 4.3). The first of these committees was formed in Leicester, and the scheme was later rolled out nationally.[11]

In other cases new plants were built under government control from the outset. Some of these were placed adjacent to existing commercial concerns already engaged in similar work, with those companies providing expertise in the design and operation of the new factories. This was the procedure followed in the case of both 'Projectile' factories (Section 4.3), factories for producing explosives (Section 4.2), and small arms ammunition (Section 4.5). Other establishments, such as many of the shell-filling factories (Section 4.4), were built from scratch by the Ministry and directly controlled by it.

The third route by which a site might become a 'National Factory' was where a contract was initially issued to a commercial firm, but the company proved unwilling or incapable of fulfilling the contract to the satisfaction of the Ministry. In these cases factories could be 'Nationalised' and a change of management and working practice forced upon them.

In addition to these new establishments, the three historic Royal Ordnance Factories - the Royal Arsenal, Woolwich; the Royal Gunpowder Factory Waltham Abbey; and the Royal Small Arms Factory Enfield, were transferred from the War Office to the Ministry of Munitions in August 1915. The Royal Aircraft Establishment Farnborough, was transferred to the Ministry in November 1916. Another establishment which pre-dated the war was the Office of Woods, Forests and Land Revenues' wood distillation works at Coleford. This too fell under Ministry control.

Although, as its name implies, the National Factory scheme was national in concept,

considerable autonomy was given to the local manager or design team with regard to the factory layout, building design and production process. No two First World War munitions works may therefore be regarded as identical. Many of the production processes were also novel. For example, the use of amatol as a shell filling (a mixture of ammonium nitrate and TNT) was introduced during the First World War. In this sense each production plant may be seen to be experimental, with considerable variations in process, reflected in site layout, between different factories. They do, however, exhibit a number of design features in common, including building materials, construction styles, and in the methods of production flow and safety features adopted. Themes and similarities can be identified, not only among factories involved in similar types of production, but also across the National Factories as a whole.

First World War munitions factories are also good examples of early 20th-century factory design which combine the principles of `scientific management' and the wish to substitute skilled operatives for unskilled or semi-skilled labour - a process known as `dilution'. This involved splitting the production process down into a series of repetitive tasks which could be carried out quickly by employees with little training and experience. This produced munitions at a high rate, although in the explosives industry this was also done as a safety measure. A number of 'production-line' style manufacturing methods were also adopted which would become commonplace after the war. In short, the purpose-built National Factories brought significant innovations in industrial design, industrial processes and welfare standards, which formed the basis for the layout or methods of working of many later factories in Britain.

Following the end of the conflict in November 1918 most of the National Factories were closed, the more specialised ones demolished, and others adapted to new uses. Today only a small number of the original factories or buildings remain extant. Of these many of the surviving buildings are those which were built pre-war and adapted only temporarily to munitions work. Of the purpose-built National Factories remarkably little survives a century later.

Definitions

The official *History of the Ministry of Munitions* itself acknowledges that 'Considerable difficulty has been experienced in defining the term "National Factory"'.[12] The *History* goes on to explain that the list of factories directly controlled by the Ministry would have been quite small. A number of factories were run by private companies, but this was carried out under an agency scheme whereby the entire construction and running of the plant was funded by the Ministry, and the companies paid on a 'cost plus percentage' basis. Thus the extent to which a factory could be considered strictly 'National' was variable. When the *History* was compiled, however, a numbered list of 218 'National Factories controlled by the Ministry of Munitions' was published.[13] It is this list (however arbitrary) which forms the basis for this project and this report.

3. FACTORY DESIGN AND BUILDING TYPES

Construction, building materials

As will be described in the following sections, many National Factories occupied premises constructed before the outbreak of war. Some of these were factory buildings where activities very similar to the wartime role of those plants, such as metalworking and engineering, were carried on. Other factories were established in emergency accommodation which had previously been intended for other purposes. Tram depots, drill halls, and all manner of other commercial premises, including at least one cinema, were taken over as National Factory sites. To address the diversity of all of these types of buildings would be beyond the scope of this report, however a number of sites were either constructed from scratch during the war, or had additional buildings added to an existing site between 1915 and 1918. The construction materials and style of these wartime buildings exhibit certain typical characteristics which can be identified, and these form the focus of this section.

In most cases the emphasis was on low cost and quick construction with readily available materials. Timber huts were chosen in many cases as a solution to these requirements, but a host of other materials including corrugated iron, concrete slab, asbestos, and plaster were used where timber was unavailable or expensive. These types of buildings also offered the advantage of being frangible in the event of an explosion and so were frequently used as the location for shell-filling and other dangerous processes. Some processes, particularly heavy engineering and chemical manufacture, required larger and more solidly constructed facilities, and here brick and concrete were used as necessary.

The construction of a typical timber-framed hut was described in an article in *The Builder* in 1916:

> The cheapest and most usual type of building, as before stated, is constructed of wood studding covered with weather boarding or corrugated-iron sheeting, and roofed either with boarding and felt, open slates or asbestos tiles, or with corrugated-iron. Weather boarding is cheaper than iron and is more easily obtained. Upon the other hand iron makes a more weather proof building.[14]

The diversity of materials which might be used, and the limited availability of each, was in some circumstances turned to the advantage of the Ministry. This was described in a speech detailing the construction of Coventry National Fuse Filling Factory, given by the Ministry of Works architect Sir Frank Baines in 1919:

> The main shops were constructed on four different systems in order to spread the work over as many trades as possible: one range of shops being constructed with brick walls and piers rendered externally in cement. The second range is constructed with a brick base to the floor level and hollow terra-cotta block walling above in two thicknesses between brick piers, the whole being rendered externally. A third range is formed of breeze concrete slabs between

> brick piers rendered externally in cement and plastered internally in hard plaster. The fourth and last range of main shops is constructed with brick base and walls of timber-framing covered externally with weather boarding and felted and lined internally with asbestos sheets.[15]

All of these structures, however, conformed to a standard plan, being long single-storey blocks 50 feet wide with a two-span saw-tooth roof. This was slated and fitted with glazed north-lights.

For larger structures steel frames and trusses were used, often clad with metallic sheeting. An example of this is the National Projectile Factory at Templeborough near Sheffield (Fig 3.1). Here the main workshop was constructed of steel-framed bays 18 feet wide, with external walls formed of galvanised iron sheeting. Light was admitted though a pitched roof glazed on both sides The whole building was said to have required 1800 tons of steel and 400 tons of glass to complete.[16]

Fig. 3.1. NPF Sheffield (Templeborough) machining shop under construction, 24 November 1915 (TNA MUN5/157).

The office buildings at the same site were constructed of concrete by a novel method using what were essentially paving slabs laid on edge:

> Their construction is interesting. The inside, outside and partition walls are entirely made from moulded concrete slabs 2ft square and 2½ in thick. Primarily intended for pavement making, they form excellent building material, for they become dry and hard very quickly. They are cemented together along their edges so that the walls are everywhere only 2½ in. thick. In addition to cement small steel U-shaped pieces are used to bind each neighbouring pair of slabs together. The inside and outside walls are stiffened at intervals of 29ft by pillars of reinforced concrete, and on the outside, facing the road, the wall is roughcast.[17]

Concrete was also used in other unorthodox ways. One technique was to erect 'steel lathing' consisting of expanded metal mesh in panels between steel or timber framing and then render it directly with cement. This had the disadvantage that it was quite time-consuming to create, required skilled labour and could not be carried out in frosty weather. However, according the *The Builder* in 1916 'a building of

semi-permanent character' could be constructed by this method.[18]

Significant attention was given by architects and engineers to the question of how to roof these structures, both efficiently and economically. Prior to 1914 the 'saw-tooth' factory roof fitted with glazing on the northern side ('north-lit') was widely considered a standard for roofing single-storey industrial buildings. Architect Herbert Buckley described this arrangement in 1920 as the '*sine qua non*' of pre-war factory building.[19] Such roofs could be constructed on either a steel or timber frame, or of reinforced concrete, and clad with a variety of materials. This roofing style was often used to span individual bays within a larger factory, with rows of piers or stanchions supporting each roof truss. The roofs at NPF Templeborough, and NFF Coventry (discussed earlier) were supported in this fashion. It was possible, however, to create a roof which was of this external character, but with a single uninterrupted internal span. This was the case at the empty-shell stores built on the north site at NFF Hereford, Rotherwas (Fig 3.2). Not only was this roof robust enough to support its own weight without internal stanchions, it also carried a series of rails for a travelling crane system for moving shells around the internal space. Unfortunately such roofing systems, while impressive, consumed very significant amounts of steel and economy of materials was often a higher priority.

Another distinctive feature of the saw-tooth roofs on a number of the 1915-18 period buildings at Rotherwas is the use of an external linking beam connecting the apex of each truss. This style of construction appears to have been characteristic of a number

Fig 3.2. NFF Hereford, shell store with a north light roof and a complex pattern of runner beams for overhead cranes (M Bellamy).

of National Factory buildings. Other examples of this roof survive at the National Aircraft Factory at Heaton Chapel near Manchester, and the Trench Warfare Filling Factory at Walthamstow in London.

Where roofing was constructed from timber, the so-called 'Belfast' truss was also commonly utilised. This took the form of a shallow 'D' shaped truss created from a large number of small timbers. It had the advantage that no large beams were required, and the whole truss could be created from 1½ inch and 2 inch planks of standard stock sizes. Nor was any complicated jointing required. The whole was secured together simply by nails and bolts. Large spans of up to 50 feet could be roofed using this technique. There were, however a number of drawbacks. The curved external roof which resulted made cladding or tiling the structure more complex, and it also made the insertion of roof glazing more difficult. The dense woodwork required also cut down light from skylights, and made the installation of drive shafts and belting in the roof spaces problematic. Nor was it a very strong design if any equipment was required to be suspended from the trusses. Herbert Buckley, in the speech quoted earlier from 1920 remarked:

> A return to normal conditions would doubtless result in a return to the former methods of construction, and although the 'Belfast' roof has stood us in good stead during the past few years, the speaker hardly thought it was likely to be largely adopted when other forms of roof could be employed in which materials of a more durable description than felt and materials of a similar character could be used for an external covering.[20]

Fig. 3.3. NPF Birtley, surviving Belfast Truss roof in the former canteen building (W Cocroft).

Despite these reservations, Belfast truss roofing was used in a number of National Factories. The surviving canteen at the National Projectile Factory at Birtley exhibits a Belfast roof (Fig 3.3), and photographs survive of now demolished examples used for stores buildings at the National Filling Factories at Leeds (Barnbow), Liverpool and Gloucester. Many other examples were constructed at other sites.

Production flow

In addition to simply creating a building within which munitions work could be carried out, where possible, consideration was also given to the efficient flow of materials through the factories, and to mass-production techniques. As Herbert Buckley put it:

> With regard to the development of the plan it almost went without saying that the raw material should enter at one end of the factory and the finished product emerge from the other.[21]

These ideas were already circulating within industry, Henry Ford, for example having installed a moving assembly line in his factory in Michigan in 1913. A similar production line was also installed in the Ford factory at Trafford Park, near Manchester in 1914.[22]

Within the pre-war munitions industry, however, the precision required in many tasks meant that a craftsman-led culture still prevailed. At the Royal Small Arms Factory at Enfield, for example, rifle assembly and finishing was still carried out for complete weapons by individual high-skilled workers at their own work benches. If production was to be massively increased, and large numbers of new unskilled workers employed, these methods would simply not be viable. The solution to this was the concept of 'dilution' whereby complex tasks which had previously been undertaken by a single skilled employee were broken down into a number of simple repetitive steps which could be carried out by an employee with relatively basic training. Opposition to this system, and in particular to the opportunities it created for the employment of women, continued throughout the war within the trade unions representing skilled workers. Indeed the problem in some industries became so acute that it became the reason why certain factories were nationalised. For example the National Radiator Factories at Greet and Sudbury were established after the private contractor proved unable to overcome opposition to increased production from the Sheet Metal Workers Union.[23] In spite of these problems, dilution nonetheless became the model for manufacturing processes used by the Ministry in National Factories. High levels of dilution were more easily obtained at newly built factories where no existing working practices had to be overcome. As a result the new Filling Factories, for example, applied the technique very widely, and it is no coincidence that these sites also employed large numbers of women.

Two other obstacles stood in the way of efficient modern production methods. The first of these was the fact that, as described earlier, many National Factories were established in pre-existing buildings which were often crowded and unsuitable. Even where a factory continued to carry on work similar to that which it had done pre-war, often many more machine tools were squeezed into already crowded

factory spaces, and storage of raw materials and finished product could also become an issue. A second problem was explosive safety. Although many of the explosive manufacturing and filling sites were laid out as scientifically as possible, a completely uninterrupted production flow would have been highly vulnerable to accidents. Thus batch production had to be used on these sites, with small amounts of explosive material being brought from stores and processed, then moved on before a new batch was introduced. One way of overcoming the slowness of this process was to set up a number of parallel production facilities, each separated from its neighbours and protected by earth bunds as necessary. It was these multiple rows of production lines, with each process carried out in separate small huts, which gave the Filling Factories, in particular, their characteristic appearance.

However, where neither of the problems presented themselves, and non-explosive processes were carried out on newly-built sites, the full benefit of modern scientific manufacturing methods could be applied. An example of this was the National Projectile Factory at Templeborough, where raw materials in the form of forged shell cases entered the factory on one side via ramps, and were then turned on a series of lathes running across the building before entering a lacquering shop and then being discharged on the other side of the building. (More detail on this is contained in section 4.3 below.) In another case, the National Timber Drying Kiln at Swindon was designed so that material could be pushed through the building on wagons rolling down an inclined ramp, allowing the kiln to run constantly with material being pushed in one end, and emerging fully dried at the other.

Architects and architectural adornment

The science of efficient production was not the only consideration in the creation of the National Factories. The design and layout of the newly established factories, in particular, lay in the hands of the architects of the Office of Works. Having previously been peace-time architects, these men retained aesthetic sensibilities which were not entirely obscured by the needs of war. One architect in particular, Sir Frank Baines, was responsible for a number of National Factories, and his buildings are notable in many cases for their decorative as well as functional character. Baines had begun his career as an articled pupil of the architect C R Ashbee, a significant figure in the Arts and Crafts movement, before joining the Government's Office of Works in 1895 at the age of 22, as a draftsman at Hampton Court Palace. Much of the work of the Office of Works was concerned with the restoration and maintenance of nationally important historic buildings, and this left Baines with a strong sense of history, and an affinity for Arts and Crafts ideas.[24] By the time of the outbreak of war he was one of the two principal architects in the Office. One example of his work is the administrative office building at NFF Hereford (Fig 3.4), which still stands (see Appendix B), and includes not only a decorative portico but also a roof-top cupola and clock. He was also responsible for a number of workers' housing schemes (discussed below).

A number of other factory buildings were built incorporating decorative architectural features. In the case of larger brick and stone structures it would seem that to include detailing such as cornicing, or decorative brickwork was not considered an undue

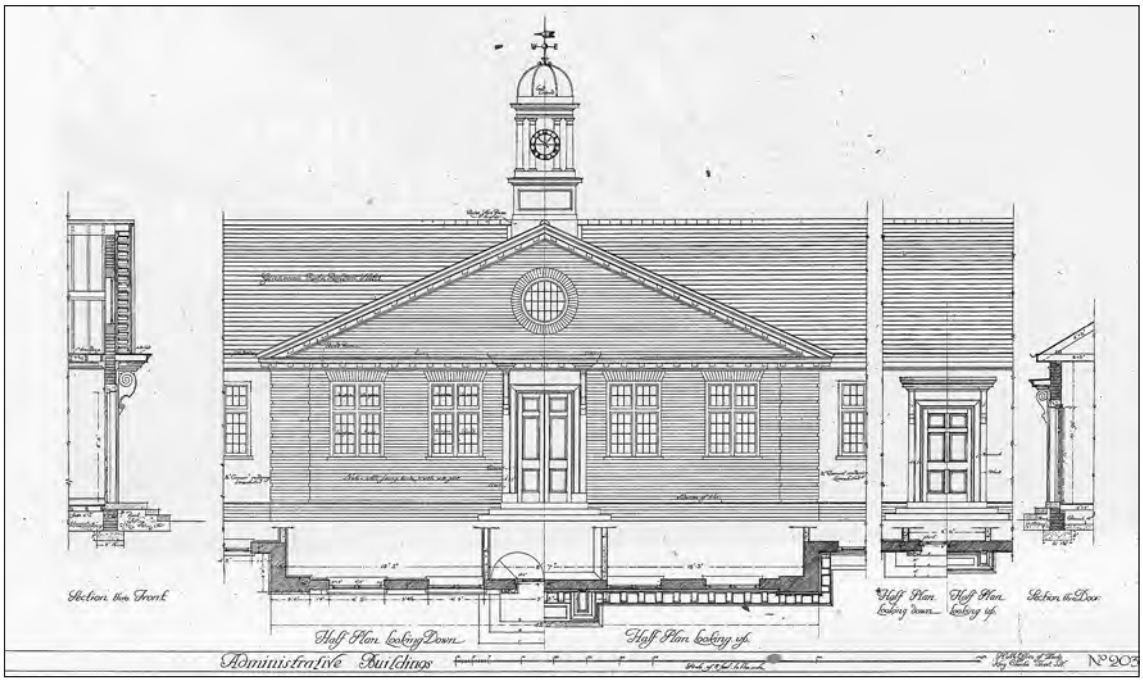


Fig. 3.4. NFF Hereford, design by Sir Frank Baines for an office block (reproduced in The Builder *March 21 1919).*

luxury. Arguably it was almost as quick and cheap to create an architecturally pleasing building as it was to build an unadorned one. Examples include the office building at the cordite site at Mossband, (part of the explosives complex at Gretna), and the office building at HMEF Avonmouth (see Fig. 4.11). Both of these buildings have been demolished since the 1990s. One surviving, and very impressive office building is that built at the National Machine Gun Factory at Burton on Trent (see Appendix B) (Fig 3.5). This building is a monumental three-story structure with a clock tower and decorative stonework. It is now designated a Grade II listed building.

Power supply

All National Factories required a power supply. In most cases electricity was used as the main motive power for machines. Some machines were powered directly but in many factories electrically driven shafts were installed in the eaves of factory buildings providing power to a number of machines via belts. This method was used in particular at several of the National Projectile Factories, including Dudley and Templeborough, where shells were passed through a number of turning and machining operations arranged on adjacent machines (Fig 3.6).

Smaller factories could rely on local service providers, for example Hereford and Banbury Filling Factories took electricity and gas from the local town suppliers. Similarly NFF Leeds (Barnbow) took electricity from a local commercial supplier.[25] Other sites created their own power in on-site boiler houses. These had the advantage of creating steam which could both be used to create electricity via generators but also be pumped as heating, or where required, used for manufacturing purposes. At RGPF Waltham Abbey, for example, a large power

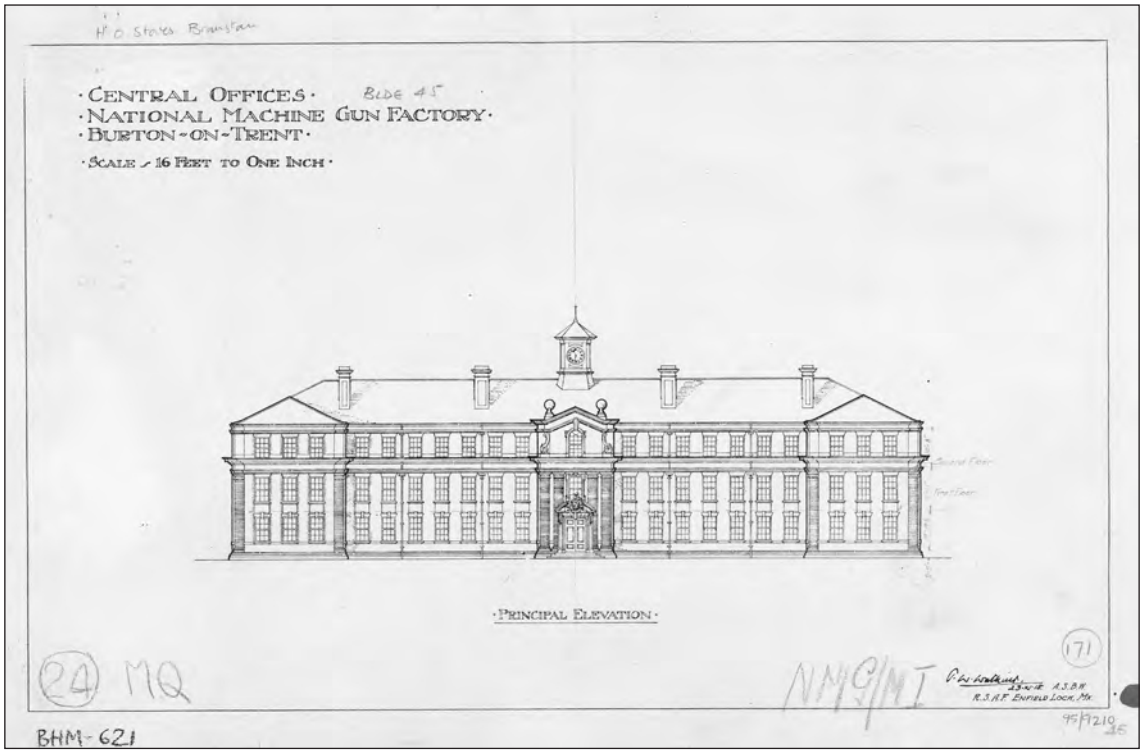


Fig. 3.5. NMGF Burton on Trent, elevation drawing of office buildings (© Historic England MD95/09210).

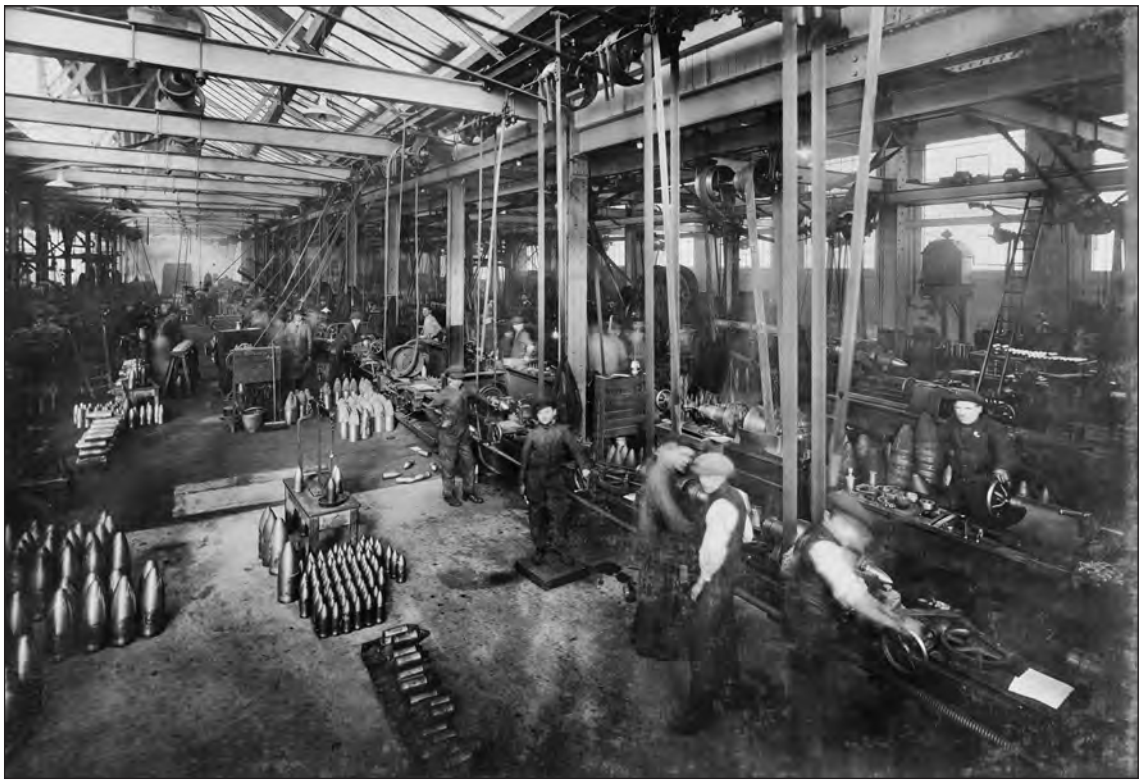


Fig. 3.6. NPF Dudley, No.1 Machine Shop showing shafts and belts for driving machines (© Historic England BB88/07423).

house was constructed shortly before the outbreak of war that not only produced steam and electricity but also powered a hydraulic pump. This building, which still survives although converted into offices, was extended in 1916 to accommodate the increased demands of the enlarged factory.[26] Other surviving examples include the electrical power plant building at NFF Morecambe (see Appendix B), and the boiler house and electricity substations at NPF Birtley (Fig 3.7). These buildings typically lack the architectural pretensions of the offices discussed in the previous section, but were nonetheless vital to the operation of the factories.

Fig 3.7. NPF Birtley, surviving electricity sub-station (W Cocroft).

Transport

It was vital that all National Factories were provided with good transport links, both externally to bring raw materials and staff to the factories, but also internally for moving materials around within the factories themselves. The cornerstone of this transport system was the railways. Virtually all factories were located next to, or had links built to, the national railway network. Only in a few exceptional cases was this not possible, and it was sufficiently unusual for the official *History* to comment on the fact, an example being the National Projectile Factory at Dudley, which was up a steep hill from the nearest railway. Here the Ministry was also obliged to pay compensation to the local council for the damage that moving shells by motor lorry caused to the town's roads.[27] Clearly a direct rail link was preferable.

Assuming a siding could be constructed, standard gauge railways were used to bring materials right into the factory sites, and to take away finished products. The layout

of many factories reflects this with the buildings lying inside a loop of track, as at the Filling Factories at Gloucester, Leeds, and Hereford, or between parallel tracks, such as at Banbury (Fig 3.8). Such sites also had large areas of sidings to allow marshalling of wagons. NFF Hereford was provided with 27 miles of standard gauge track in total within the factory site.[28] While much of this track has been removed, earthworks associated with rail cuttings and embankments survive at a number of sites, including for example Banbury, Leeds (Barnbow) and Hereford. Crop marks indicating the former railway lines at NFF Liverpool No.2 are also visible on the adjacent Bootle Golf Course.

Fig. 3.8. NFF Banbury, aerial photograph showing earthworks associated with former railway lines on the factory site (© Historic England 27784/040).

In some cases it was also necessary to create new passenger stations on existing rail lines in order for workers to get to and from the factories (Fig 3.9). An example of this is the Fuse Filling Factory at Luton, where a new station was opened adjacent to the factory at Chaul End, on the Great Northern Railway Line. This was opened to passengers in 1915 but closed again rapidly after the war in 1919 and was demolished.[29] In other cases existing stations sufficed, but special trains were run at convenient times for the various shifts within the factories.

Specially chartered motor buses were also used at some sites to transport workers to and from the factories. For example bus services from Loughton and other surrounding areas were provided to bring workers to RGPF Waltham Abbey. Other workers walked or cycled. Plans of a number of factories show bicycle sheds, for

Fig. 3.9. NFF Chilwell, workers awaiting the 5.08pm train at Attenborough station, 5 August 1918 (© Historic England AA96/03573).

example at HMEF Swindon, and NFF Hereford, where cycle sheds are described as part of the entrance complex.[30]

Material was moved internally within the factories via a range of narrow gauge railway and trolley systems. At their simplest these systems consisted of hand-pushed trucks running on rails built into the clean-ways which connected the factory buildings. In factories where there was a risk of explosion from friction or sparks these systems either used gunmetal or hardwood rails, or in some cases bronze wheels for the trucks.[31] Where possible, particularly in shell filling factories, level sites were obtained which permitted materials to be moved and processed throughout the site without having to be raised or lowered. Not only were the trolley tracks and clean-ways all at a uniform level but also the trolleys themselves and the workbenches were set at an even height so that shells could simply be rolled off the trolleys, worked on, and rolled on again. This system is depicted diagrammatically in contemporary drawings of NFF Banbury (Fig. 3.10).

Larger mechanically powered narrow gauge railway systems were also utilised at several sites. RGPF Waltham Abbey, for example, was equipped with a narrow gauge railway system which ran throughout, and connected the north and south factory sites. The motive power on these lines was provided by Rushton and Procter locomotives, acquired in 1917.[32] These engines used a paraffin-electric propulsion system which was extremely novel at the time, but was adopted for the practical reason that steam locomotives gave off too many sparks via their funnels and

© HISTORIC ENGLAND

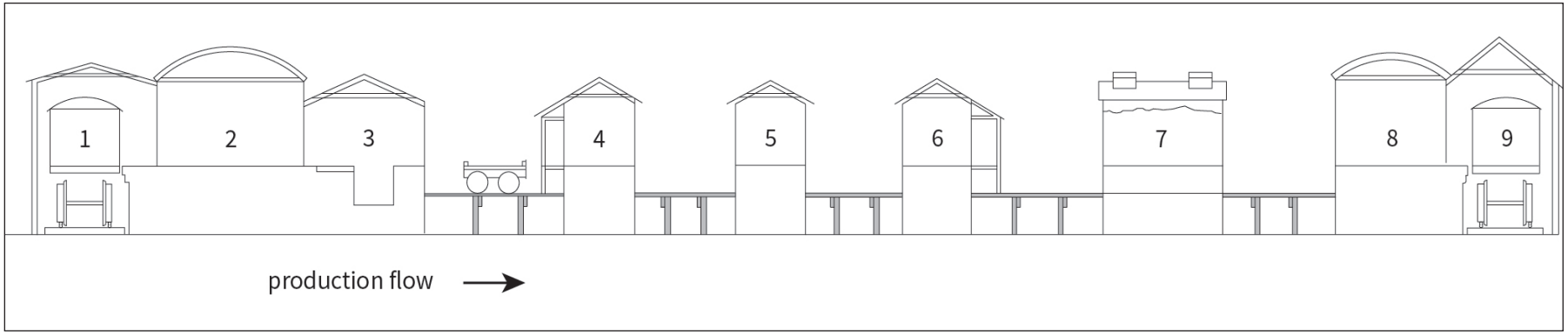


Fig 3.10. NFF Banbury, diagrammatic representation of shell-filling process (redrawn from TNA MUN5/155/122.3/51).

1 Railway wagon 2 Empty shell store 3 Shell cleaning floor with pit for workers 4 Cap-inserting house 5 Charge-typing house 6 Shell-filling house 7 Assembling shed 8 Filled Shell magazine 9 Railway wagon.

would be a fire risk in an explosives factory. Waltham also took advantage of its historic canal system whereby many production buildings were linked by waterways constructed in the 19th century. This system, too, had obvious safety advantages, but was too labour intensive a method to be developed under wartime conditions at other sites, and in any case was at least partly inspired by the riverside location of the Waltham Abbey factory.

Narrow gauge railways were also used at Woolwich, and at Filling Factories including Gloucester and Leeds. In the latter cases these were initially intended to be hand-pushed, but at Leeds pony haulage was also used. The use of animals had initially been considered unsuitable on sites handling explosives, but these rules were relaxed during 1916. The ponies were not, however, allowed to be stabled on site, and has to be brought in for each shift.[33]

Welfare provision

Great War munitions factories have become rather notorious in popular memory for their harsh working conditions; long hours, the danger of explosions, and the risks of long term ill-health resulting from handling toxic materials. As with many other perceptions of the First World War the reality of life in these factories was more complex. In factories where explosives were handled there was, of course, an ever-present risk of explosion and fire. A number of explosions occurred, the most serious and well-known of these were the explosion at NFF Chilwell on 1 July 1918, which killed 134 workers and injured a further 250,[34] and the explosion at the privately owned TNT factory at Silvertown in east London on 19 January 1917, which killed 16 workers, but more controversially also killed 53 local residents as the factory was located in a densely populated residential area.[35] On the other hand, the RGPF at Waltham Abbey produced cordite throughout the war without a single fatality. Given the dramatic expansion of the industry in a short period the number of serious incidents was comparatively small.

Ill-health was a more widespread problem. The yellowing of the skin associated with work on picric acid and the nick-name 'canaries' for sufferers, were already known before the war, but continued to be a problem. There were also cases of toxic jaundice caused by exposure to TNT. Over 100 women died from this condition in the course of the war. However, as these issues were identified, increased protective clothing was introduced, and better handling methods applied to protect workers from these ill-effects.[36] Perhaps the most hazardous environment in which to work was in the production of mustard gas, sometimes known by the British abbreviation HS ("hun stuff"), and its associated shell-filling. This work caused in some instances sickness rates equivalent to whole shifts having to be replaced.[37] Again rapid changes in production methods were introduced, and in the event, the Armistice meant that this work was only carried on for a short period in the latter part of 1918.

Provision of in-house medical care became the norm at all National Factories, and all had at least a duty nurse and surgery. As described by Herbert Buckland:

> No factory could be regarded as well equipped unless it possessed

> a surgery with a trained nurse in charge. This should be specially designed for the purpose and should comprise a surgery, restroom, store and nurses' room. In factories where both sexes are employed a second room was desirable.[38]

Reference to 'both sexes' also acknowledges the wider welfare issue which arose around the number of women being employed in National Factories from 1916 onwards. Numbers rose rapidly in that year. Lloyd George quoted figures in his memoirs stating that in the metal and chemical industries (the two key parts of munitions manufacture) employment of women and girls rose from 82,589 in July 1914 to 340,844 in July 1916. By the time of the Armistice in 1918, 1,587,300 women were working on government contracts of various kinds, mostly within industries supplying or administering the war effort.[39]

Provisions for the welfare of these women were laid out in the Munitions of War (Amendment) Act of January 1916, which, amongst other requirements, enforced the employment of women supervisors in all factories employing women or young people.[40] The difficulties in hiring a suitable Lady Supervisor are illustrated in papers relating to RGPF Waltham Abbey which survive in The National Archives. In accordance with the Munitions of War Acts, Colonel Fisher, Superintendent of RGPF Waltham Abbey and RSAF Enfield, was obliged to find a Lady Superintendent for each factory. In a memorandum of February 1916 he observed that he was already interviewing for the post at RSAF, and that:

> I am anxious to get the appointment at RGPF made and confirmed as soon as possible [...]
>
> I understand also that there is some competition for Lady Superintendents of a desirable type in munitions factories, and it is desirable to secure such suitable women while they are to be got.[41]

Unfortunately Colonel Fisher's first appointment was not successful. Miss Hilda Walton (formerly of Somerville College, Oxford) took up the position at the end of March 1916, but resigned two months later, stating as grounds the lack of suitable accommodation for her work and the small number of women employed. Fortunately a replacement was found in the form of Miss Jessie O'Brien, who had previous supervisory experience at University College Hospital in London.[42] It is notable that while both of these women were no doubt of high professional calibre, both were un-marrried. While this may be coincidence it was still the case that remaining single was regarded as the norm for those women pursuing a professional career.

At around the same time, a female Assistant Medical Officer (AMO), Dr Alice Burn, was also recruited to deal with women workers at Waltham Abbey and Enfield, reporting to the male Senior Medical Officer. While she was able to deal with women workers satisfactorily, the SMO noted in his report in February 1917:

> Unfortunately Dr Burn's help cannot be counted upon on the male side in time of stress, because prejudice exists among the men to be attended by a lady doctor.[43]

Nor were the complaints of lack of facilities made by Miss Walton unjustified. It appears that when the first women arrived at both sites little had been done by way of preparation for their arrival. Dr Burn's own report sums up the situation, in relation to medical facilities at RSAF:

> Accommodation
>
> During the first month – Nil. Medical examinations of workers conducted behind a screen in passage way of old Recreation Hall, in use as a temporary canteen. Subsequently one room partially partitioned off from main building served as office, surgery and examination room. Here, for five months, the work of the women's medical department was carried on, without artificial light, water or heat, except such as the adjacent canteen afforded. [...]
>
> The disabilities associated with the grossly unhygienic accommodation of practically eight months of 1916 plus inadequate equipment are too obvious to need further comment.[44]

Her colleague in the Welfare Department of RSAF was in a similar situation:

> When I was appointed the head of the Women's Welfare Department RSAF on April 2nd 1916, there was no department, and I had neither office to sit in, or chair to sit on! Within a few days I was shewn [sic] an unused wooden building just outside the Factory, and asked if I would make temporary use of it, until proper accommodation could be built for the department. As it was a roof over our heads and I was anxious to get to work, I was ready to make the best use I could of any space available.[45]

Thankfully most of these difficulties were temporary, and by 1917 a significant amount of new infrastructure was in place to meet the needs of the increasingly large number of women workers. New facilities at Waltham Abbey included a newly built women's hospital, complete with operating room which was constructed in late 1916 (Fig 3.11).[46] At RGPF this was essential as by 1918 almost half of the workforce were female. Other sites had an even greater proportion of female workers, in particular the newly-built filling factories where the proportion of women in the workforce reached as high as 85%.

Work-place health and safety was, however, only one part of the picture. The Ministry of Munitions was keen to maximise production, and this meant not only that accidents which both killed workers and interfered with production should be kept to a minimum, but also that workers should be kept healthy, and broadly speaking, happy. A second area where significant changes occurred relative to pre-war factory practice was in the provision of canteens. Formerly workers were expected to bring food from home, to go home at meal times, or to visit local hostelries. It was rapidly appreciated by the Ministry that this was inefficient, and in some cases the vast increase in the workforce at particular factories was overwhelming the local services. Shift work also increased the problem with workers wanting to eat at unusual hours. Added to this was the restriction on public house

opening hours included in the Defence of the Realm Act, intended to cut down on time lost to alcohol-related absenteeism. One unintended consequence of this occurred at RSAF Enfield, where night-shift workers, accustomed to take their meal break in the local pubs, were angry to discover that these establishments had been forced to close at 11.00pm before their meal break began. The local solution there was to allow the pubs to stay open an extra hour,[47] but more widely, the provision of on-site canteens was the longer-term answer (Fig 3.12).

Fig. 3.11. RGPF Waltham Abbey, women's hospital (now demolished) (© Historic England BB92/26040).

The question of catering was even more pressing for women workers as it was less socially acceptable for them to eat in local pubs or other establishments, especially at unusual times of day or night. Provision of canteen services as well as other welfare provision was also strictly segregated, except on special occasions, so even where canteen provision for male staff existed, it was necessary to establish parallel facilities for women workers. A significant amount of detail about the women's canteen as well as other facilities at RSAF Enfield survives in the report from the Head of the Women's Welfare Department prepared in 1917, (quoted earlier). This document merits quotation at some length:

Fig. 3.12. NSF Liverpool (Cunard), canteen 30 September 1917 (© Historic England BL24001/032).

Canteen

We started our canteen at the end of April by simply supplying tea, bread and butter, which was all we could do until we got some equipment. Within a few weeks we had three ordinary gas cookers, and two small hot closets fixed, and bought enough plates etc. to enable us to serve dinners for 300 or so women, it was a difficult job in the small space, but we did it. It was interesting to note how the women gradually gave up bringing cold sausages etc, with them and bought the hot dinners we supplied. We now have a splendid canteen equipped with everything we can possibly need, and capable of serving 500 women at a sitting. We have made a great point of finding out from the women themselves what they like in the way of food, and have always when possible cooked any special dishes they may fancy. I feel that the great point is to stop the bringing of cold food which has probably been packed up overnight, and kept in a bag in the shop during the morning, and gradually educate the women to eat a freshly cooked meal. As our numbers in the canteen are increasing daily, I can but feel that the method we used to cater for the women has been the right one. We have daily a choice of four or five meat dishes, fish, fruit tarts, stewed fruits, milk

> puddings, pastries etc. For women who prefer lighter food, there is always a plentiful supply of lentil, and other soups, eggs, rice balls, and a variety of four or five vegetables.
>
> Recreation Room
>
> Our recreation room was opened with a dance on February 10th which was attended by 500 men and women. We are now able to arrange classes and lectures for the women, and here again we are asking the women to say what classes they would like, and we will do our best to arrange them. Lectures of First Aid and Hygiene are given by the A.M.O. These we have not been able to arrange for before as I did not think it wise to have lectures of any sort in the Canteen (which was the only available room) during the dinner hour, as the women who did not wish to listen to a lecture, had nowhere else to go until the Recreation Room was opened. We can now arrange all our classes and lectures at any time during the afternoon and evening in the Recreation Room, and no woman need be present who does not wish to be. Gymnasium, dancing, and embroidery classes have already been arranged. The women have subscribed together and bought a piano. We hope to have constant dances and entertainments.
>
> Shift Room
>
> A Shift Room has been built to accommodate 2000 women. Joined onto this is a Sewing Room, where overalls are made and repaired. This room is not used at night as it is next to the Women's Surgery. I have the fire burning all night so if the night nurse thinks it is advisable for a woman who is feeling ill to rest for ½ an hour and wishes to help her under her own eye during that time, she can make her comfortable in there, instead of sending her down to the rest room.
>
> Hostel
>
> A Hostel to accommodate 32 women has been opened, and is gradually filling up; the women much appreciate the quietness and comfort provided for them there.[48]

A certain self-satisfaction may be detected in the tone of this document, but given the challenges faced, and the total lack of any form of infrastructure at all only a year before, the achievements of the Department were indeed quite remarkable.

The account above describes the integration of new facilities into an existing factory. Where new factories were built from scratch these kinds of facilities were included from the outset. The canteen building at Birtley with its Belfast truss roof has been mentioned earlier, and other sites had similar arrangements. A particularly striking

surviving example is the canteen complex at the National Machine Gun Factory at Branston. This building included both male and female canteens, along with surgeries and a social club, and was equipped externally with a bowling green. Although only single storey, the building was constructed of brick and stone to a high architectural standard, with decorative details to match the adjacent administration building. This structure is now designated a Grade II listed building.

Housing schemes

In addition to providing transport for workers to the National Factories, as described above, in some cases it was found necessary to provide them with purpose-built accommodation. Although most sites were located near to existing towns and cities, and many workers were either recruited from the local area or billeted in the homes of local people (as was the case at Hereford), at some sites the influx of workers was so large that existing facilities simply could not cope.

Fig. 3.13. Royal Arsenal Woolwich, workers housing: angled corner block on Prince Rupert Road, Well Hall Estate (© Historic England BB96/227).

This requirement was recognised early in the war before the Ministry of Munitions had been created. In late 1914 it was found that the number of workers at the Royal Arsenal, Woolwich was likely to increase significantly, and extra housing would be needed. Due to a pre-war recession in the building industry there was already

a housing shortage in 1914, and the government took the long view that any new housing that was built should be of a permanent character which could continue in use after the conflict was over. The Housing Act of 1914 (passed in order to create housing for naval dockyard workers at Rosyth) had also given the state powers to compulsorily purchase land and build houses to accommodate government workers.[49] The land chosen for Woolwich workers was the former Well Hall estate in Eltham (Fig 3.13). Well Hall itself in 1914 was the residence of E. Nesbitt, author of *The Railway Children*. A scheme was drawn up to build 1,200 houses as quickly as possible, designs were approved in January 1915, and 800 houses were complete by July, with the whole estate of over 1,200 homes finished by the end of the year.[50]

The model taken for the design of this estate was based on the garden suburbs which London County Council had been building since the 1890 Housing Act, such as Totterdown Fields, Norbury (completed in 1911), or White Hart Lane, Tottenham (where construction was halted in 1915) . These were heavily influenced by the Arts and Crafts Movement, and by the garden city ideas expressed at Letchworth, and aimed to create (perhaps slightly naively) cottage style accommodation for workers with a rural village feel.[51] Well Hall was overseen by Ministry of Works architect Frank Baines, who was a keen follower of these architectural ideas. The result was an estate laid out along curving roads, with a central 'village green' and a complex variety of historically inspired house designs with different styles and building materials.[52] The estate survives largely intact, and is protected as a Conservation Area, although no individual buildings are listed.

Another architect inspired by the same tradition was Raymond Unwin (1863-1940). He had previously been involved in the design of both Letchworth Garden

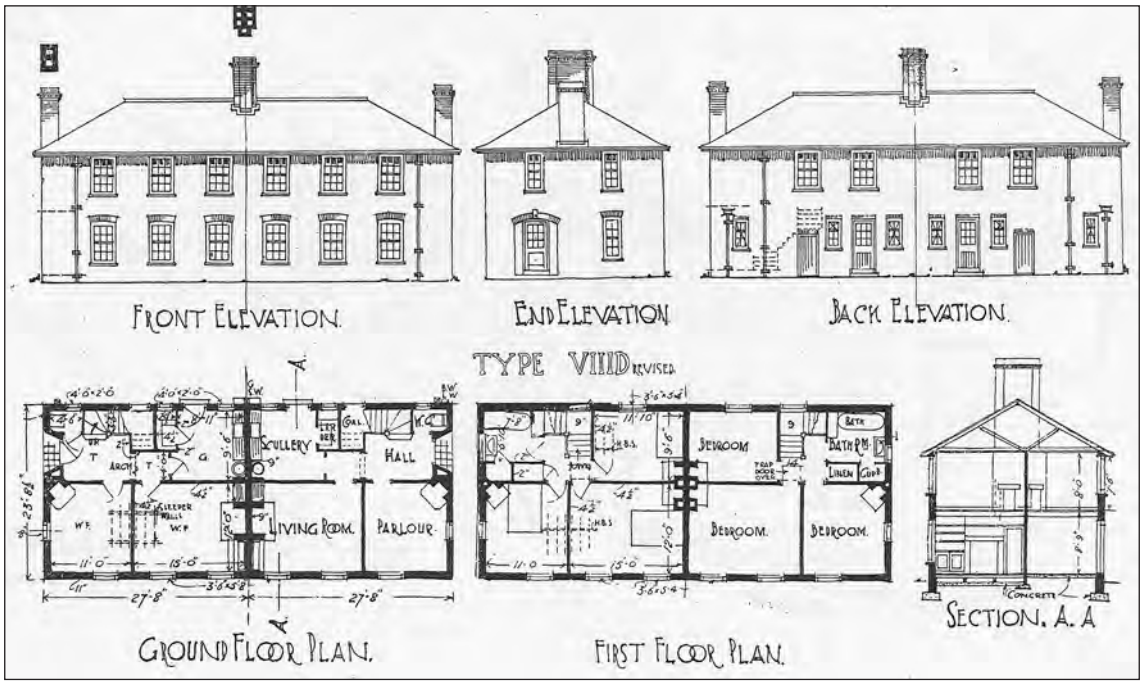


Fig. 3.14. HMEF Gretna, drawing of sample housing block (reproduced in Building News *No. 3226, 2 October 1918, p. 233).*

City and Hampstead Garden Suburb, when he was co-opted in 1915 from the Local Government Board into the Ministry of Munitions, as Head of Housing Design for the Department of Explosives Supply. Unwin was responsible for the design of workers' housing both at Gretna (Fig 3.14) and Eastriggs, in Scotland, and at Mancot Royal in Flintshire, Wales, an estate built to house workers at HMEF Queenferry near Chester. The new buildings at Gretna consisted of 287 new houses and 29 hostels, the latter convertible after the war to houses, as well as civic amenities such as shops, churches for the various denominations, police stations and public halls.[53] These were all built in a slightly more restrained neo-Georgian style rather than the cottage style of Well Hall, but the project was nonetheless on a grand scale and incorporated a good deal of architectural adornment. A similar settlement of 191 houses and six hostels was constructed at Mancot Royal to Unwin's designs. Buildings survive at both sites but the main settlements are in Scotland, Gretna and Wales, Mancot Royal (Fig 3.15).

Fig. 3.15. HMEF Queensferry, workers' housing at Mancot Royal, designed by Raymond Unwin (W Cocroft).

Not all architects favoured the taste for pleasing design and imaginative layout espoused by Baines and Unwin. Once the Ministry of Munitions became established, the responsibility for these projects passed out of the hands of the more architecturally-minded Office of Works. The Treasury also objected to the cost of these more flamboyant projects. Well Hall had finally cost nearly double the original budget.[54] Thomas Bennett, who was also an architect at the Office of Works wrote

an article in *The Builder* in 1916 where he called for a focus only on what was strictly necessary and functional:

> No special features can be introduced – every part must be absolutely necessary to the structure – [...] Housing schemes must likewise be planned upon a plain rectangular layout. Curves or unusual angles or a variety of designs and variations must be avoided. All of these things cause delay and expense, and however desirable they may be from an artistic point of view, they should under no circumstances be allowed.[55]

The only variation Bennett was prepared to countenance was in the design of houses for more senior staff, 'who demand, and rightly demand a superior dwelling to that occupied by ordinary workers.'[56] This emphasis on utilitarian rigour may have influenced Bennett's later work. He is best remembered for his work on the post-1945 new towns of Crawley and Stevenage. As the war progressed, ideas of not only the utility, but also the aesthetic and moral qualities of uniformity and mass production started to take over from earlier Arts and Crafts thinking, and this was to be a significant influence on the design of post-war housing projects.[57]

Despite the architectural debate, what is certain is that most workers housed in government accommodation did not live in garden villages but in temporary huts. At Gretna, in addition to the two 'model' settlements of Gretna and Eastriggs, many more workers were housed in simple single-storey wooden buildings. At least one of these, at 65 Pretoria Road, Eastriggs, was still occupied as a domestic dwelling into the 1990s, but has now been demolished.[58] Similarly while 1,200 houses were built at Well Hall, a further 852 temporary timber huts were also constructed in Eltham as houses for workers from the Royal Arsenal, Woolwich.[59]

One of the largest timber-hutted settlements constructed in connection with a National Factory was 'Elizabethville', built to house the Belgian refugee workers at NPF Birtley in County Durham (Fig 3.16). In total the workers and their families formed a population of over 6,000, of whom 700 were children. The bleakness and simplicity of the site was not initially very popular, especially as in the winter of 1915-16 the site was particularly muddy. The official report on the factory, contained in The National Archives, commented that 'The village looked more like a Rocky Mountain camp than any settlement previously seen in England.'[60] However, the town grew until it provided for all the workers immediate needs:

> The size of Elizabethville is shown by a summary of its buildings: village offices, police and fire station, church, schools for 700 children, provision and meat market, 22 sleeping hutments, 24 sleeping hostels, three dining halls, laundry and baths, hospital with laundry, isolation ward, nurses' pavilion, disinfector and mortuary, staff hostel, six bungalows for officials, two presbyteries, 532 three-bedroom cottages, 342 two-bedroom cottages, sewage disposal works, 17 foremen's cottages and a cemetery.[61]

Eventually life for the workers within Elizabethville was sufficiently pleasant for it to create friction with the inhabitants of local mining villages who felt that the Belgians

were receiving preferential treatment.[62] This was in part due to controversy over the allocation of rationed foodstuffs, as well as provision of accommodation, but the Belgians did have such facilities as indoor toilets and hot and cold running water in their huts, which were not necessarily commonplace in parts of wider Durham society.

The street plan of Elizabethville has been at least partially preserved in the present town layout. Originally the streets were given Belgian names, but these have now either been changed or anglicised; the Boulevard Reine Elizabeth is now Elizabeth Avenue, and the Boulevard Princesse Marie Jose is now Windsor Road. Virtually all of the temporary hutting was demolished after the war, and many of the lesser streets have been removed, replaced by later housing on different alignments, however, two surviving buildings have been identified (see Appendix B). These are the former butcher and grocery shop buildings on Rue d'Anvers, now Devon Crescent. Both are single-storey timber-framed structures, now occupied by a car repair garage.

Fig 3.16. NPF Birtley, a street in Elizabethville (TNA MUN 5/157).

4.1 ROYAL ORDNANCE FACTORIES (ROF)

Purpose

As was outlined in an earlier section, the three historic state-controlled munitions factories at Woolwich, Enfield, and Waltham Abbey were taken over as National Factories in the course of the war. These had been controlled at the outbreak of the war by the Army Board, under the Master General of the Ordnance. With the creation of the Ministry of Munitions, it was a logical step for that Ministry to take over supervision of these factories and co-ordinate their production with that of the other National Factories then being established. This change was agreed between the War Department and the Ministry of Munitions in August 1915 and thus these sites became nominally part of the National Factory programme. These factories were given the designation Royal Ordnance Factories (ROF).[63] A fourth royal factory, the Royal Aircraft Factory at Farnborough was also taken over by the Ministry in 1916. This is considered in the section on aircraft production below (4.6).

All three of these sites had been in operation for over a century by 1914. In the case of Woolwich and Waltham Abbey, and to a lesser degree Enfield, production facilities had been developed *ad hoc* over time, and in many cases the buildings in use as factories were both old and crowded, and often being put to purposes for which they were not originally constructed. These sites also continued in operation after 1918 and indeed were still in operation until the 1990s. At the time of disposal by the Ministry of Defence/Royal Ordnance all three sites were subject to detailed investigation, and reports were published on the history and surviving buildings on each.[64] It is beyond the scope of this report to repeat much of this detail here. However a brief consideration of each site, and of any new buildings or facilities erected between 1914 and 1918, is provided, in order to place any surviving Great War structures in the wider national context.

Factory Characteristics

Royal Ordnance Factory Woolwich

The Royal Ordnance Factory Woolwich was an agglomeration of earlier factories. Ammunition making on the site had begun in 1694 in a part of the site known as the Royal Laboratory. This was followed in the 1700s by facilities for gun founding (the Royal Gun Factory) and for carriage making (the Royal Carriage Factory). By 1914 the site was utilised for the manufacture of both small arms and gun ammunition, guns and their carriages, limbers and wagons, and ammunition boxes. Work on guns also included the manufacture of large calibre pieces for the Navy and for shore defence.[65]

Historically the factory buildings at Woolwich had been concentrated in the western part of the site, the land to the east consisting of marshland. When additional capacity was required much of this was obtained by making minor extensions to buildings in the western area, and to squeezing more machines into existing workshops. However, some new buildings were constructed on the marsh to the east,

in particular the small arms ammunition factory (GCF No.3, see section 4.5 below), a fuse factory and a plant for filling Quick Firing (QF) ammunition.[66]

A series of propaganda photographs were taken around the Arsenal in 1918 by George Lewis, an official photographer (Fig 4.1). Many of these are internal shots, and show processes going on in what appear to be the pre-existing workshops. However, a few images appear to show the newly-built parts of the site (for example Fig 4.1). Here single-storey brick, and timber-framed structures are visible similar to those built at other National Factory sites, connected by clean walkways raised above the surrounding ground.

Fig. 4.1. Royal Arsenal, Woolwich, women moving between danger buildings, 1918 (© IWM Q 27874).

Output from Woolwich reached its peak during 1918 with over 65,000 people employed in the various factories. This declined steadily after the war and the site contracted back into its smaller western enclave. All of the newly built 1914-1918 buildings on the eastern marshes have been demolished and the area has been redeveloped. RCHME identified 53 surviving buildings in 1994 when the site was disposed of by the Ministry of Defence (a number of these are now designated as listed buildings), but none of these was of exclusively First World War period construction.[67]

Royal Small Arms Factory Enfield

The RSAF at Enfield was concerned with the manufacture of small arms, and had been established in 1804, although much of the building stock on the site dated from an expansion of the factory completed in 1858. In 1914 the principal product from the factory was the short muzzle Lee Enfield infantry rifle, the SMLE. The factory was capable of producing around 1,000 rifles per week at the start of the war but this figure was to rise to in excess of 6,500 by 1916.[68] As with other pre-existing sites, limited space created difficulties in expanding production facilities. Much of the additional capacity at Enfield was created by switching to shift work and 24-hour production, with workers employed on six-day weeks of a 12 hour shift, and many doing additional overtime on Sundays.[69]

Nonetheless new construction did take place at the site. Comparison of site plans from 1904 and 1917[70] shows a range of new buildings, particularly on the eastern flank of the site, along a new railway siding which was constructed during the war. The official *History* gives an account of the range of new facilities constructed:

> By June 1917 in addition to the extension of the bayonet plant and the erection of a new assembling shop, the Superintendent reported progress with a new barrel mill, a new stocking shop, a new automatic screw shop, a repair shop, browning shop, machine gun shop, oil store, stores for gun stocks and new accommodation for clerical staff.[71]

Photography taken prior to the closure of the site in the 1990s recorded a number of buildings constructed during 1914-18. These included a brick-built drawing office, and a timber-framed wood store with a Belfast truss roof and superimposed skylight, a building design typical of wartime construction methods. Both of these buildings have now been demolished (Fig 4.2).

Staff numbers were also substantially increased, from around 1,800 in 1914 to 9,500 in 1918. A significant number of these new staff (nearly 1,500) were women. As a consequence of both the general increase, and the specific need to provide facilities for female staff, a number of welfare buildings were constructed including large canteens capable of seating up to 1,000 people at once.[72] A women's recreation room was also established large enough to host dances and other social functions (described earlier in section 3).

Fig. 4.2. RSAF Enfield, part of the Victorian factory shortly after closure in the 1990s (W Cocroft).

Since its closure in the 1990s, much of RSAF has been demolished. Only one central block of workshops and offices adjacent to the

canal pool has been preserved, and this is now designated a Grade II listed building. While production was carried on in this building during the First World War, it forms part of the 1858 factory and no features specific to 1914-1918 are preserved. None of the additional buildings constructed during the war on the east side of the site survive.

Royal Gunpowder Factory Waltham Abbey

In 1914 the Royal Gunpowder Factory was producing about one third of the annual national requirement for cordite, as well as guncotton, and small quantities of tetryl. The remainder of the requirement for propellant was sourced from private contractors. The factory was very old, having been established to produce gunpowder in the 17th century. With the introduction of cordite manufacture in the 1890s the site had been significantly expanded with new production facilities at Quinton Hill to the south of the older site, as well as new plant within the existing factory. Older buildings originally constructed for gunpowder manufacture had also been converted for cordite production.[73]

On the outbreak of war demand for cordite from Waltham was immediately doubled from 70 tons per week to 140 tons. This was later to rise to 250 tons by 1917. A corresponding rise in employees followed with staff numbers reaching a peak of around 6,000 by 1918; of these nearly half were women.[74] As at Enfield, much of the increase in production was achieved by running multiple shifts on existing plant, but significant new construction took place on the site between 1914 and 1918.

A variety of additional buildings was constructed across the Waltham Abbey site (Fig 4.3). These included new facilities for female staff such as shifting rooms, canteens, and a women's hospital which served staff both at RGPF and at the nearby RSAF Enfield. Almost all of these buildings have since been demolished, and indeed the entire 'South Site' of the factory at Quinton Hill has been redeveloped since the site was disposed of by MoD in the 1990s. In one area, however a substantially complete series of purpose-built 1914-1918 cordite production buildings survive on the site. Both nitro-glycerine and guncotton were manufactured separately on other parts of the RGPF site. The combination of these ingredients (along with other materials including mineral jelly and acetone) to produce cordite paste was known as 'incorporation' and this was carried out in an area to the east of the site marked on a surviving 1917 plan as the 'Cordite Factory' (see Fig. 4.3).

In 1898 a series of buildings, originally constructed from the 1860s as steam-powered gunpowder mills, were stripped-out and converted for cordite incorporation and pressing. The latter process involved the extruding of the paste into strands of varying thicknesses according to the calibre of cartridge in which it was to be used.

In addition, an adjacent former gunpowder press house was also converted to the same use. Conveniently, these buildings were already divided by blast walls into a series of individual bays into which cordite processing machinery could be placed. All these buildings are now designated as Grade I and II listed buildings.

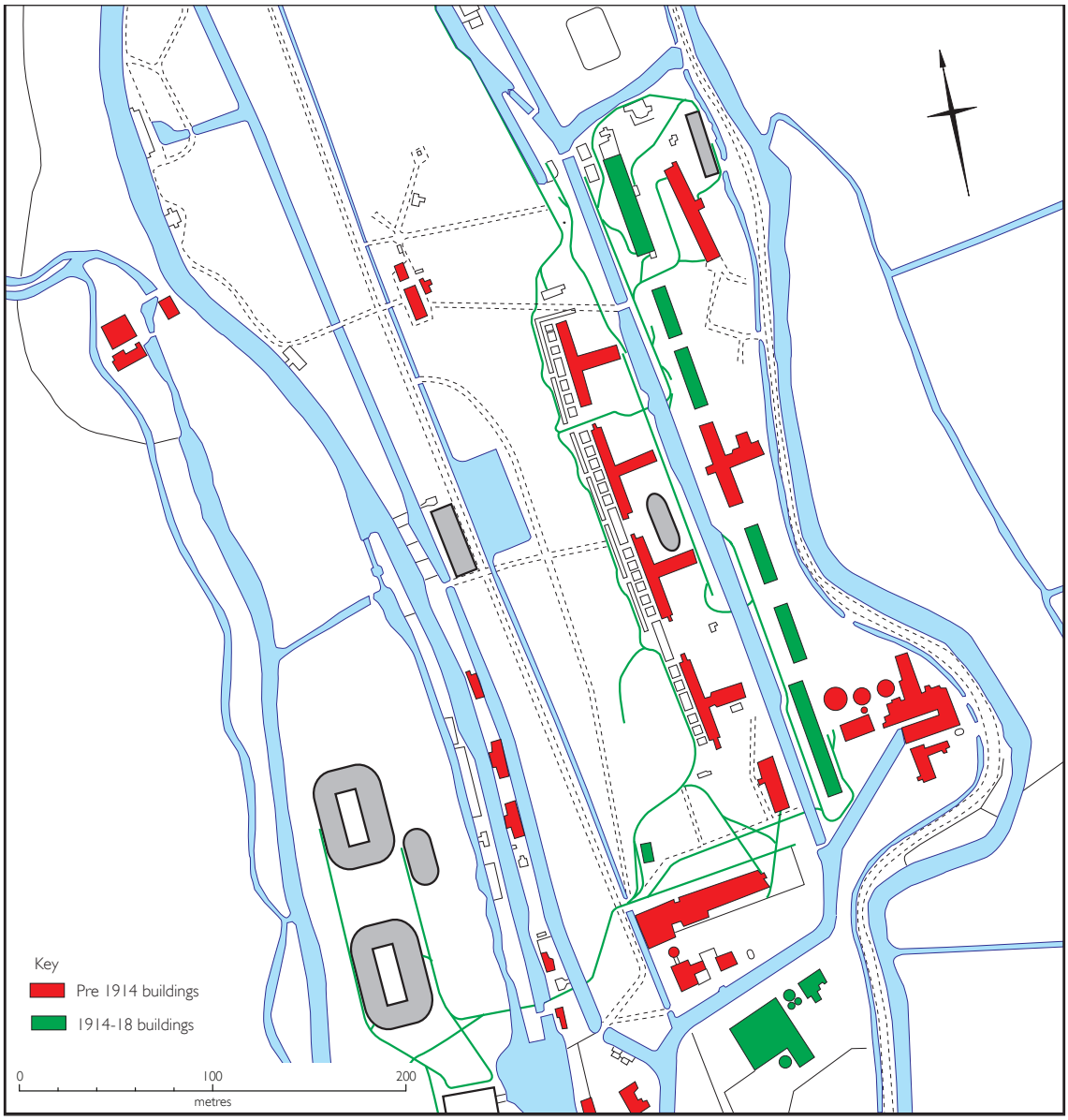


Fig. 4.3. RGPF Waltham Abbey, surviving First World War period buildings constructed to increase cordite output (redrawn from 1917 site plan held in RGM Archives).

With the demand for increased production after 1914, a further four 'Incorporating houses' and two 'Press houses' were constructed in an area of the site known as the 'Eastern Flank', to the north and south of the former gunpowder press house.[75] These buildings were similar in form to the earlier structures, being long single-storey buildings divided into a series of cells by solid brick blast walls, but otherwise constructed from light frangible materials (Fig 4.4). Machinery was powered by overhead shafts running along the eaves of the buildings, and the bearing boxes where these shafts passed through the blast walls are still extant in some places. These buildings were latterly converted into scientific laboratories, the cordite machinery was removed, and some were re-clad, but internally they remain substantially intact (see Appendix B). As at other factories, contemporary photographs show that these buildings were connected by raised wooden platforms which served as clean walkways for staff, and incorporated tramways on which

materials could be moved on hand-pushed trolleys. The new buildings were also separated from the earlier buildings across the canal by a substantial concrete blast wall, but this, along with the walkways, has been removed.

Elsewhere on the Waltham Abbey site other wartime structures survive in the form of the circular earth bunds surrounding former cordite drying stoves, although the huts forming the stoves themselves have been removed, and various concrete bases and platforms formerly part of the tetryl factory. These structures lie within the part of the site protected as a Scheduled Ancient Monument.

Fig. 4.4. RGPF Waltham Abbey, surviving cordite incorporation buildings constructed during the 1914-1918 period (© Historic England BB92/26176).

4.2 HM EXPLOSIVES FACTORIES (HMEF)

Purpose

The factories designated as 'His Majesty's Explosives Factory' are a more diverse group of facilities than some of the other factory groupings, as they carried on a range of different functions. Not only were a variety of explosives and propellants required for war purposes, but the chemical processes required to create these various products were complex and multi-stage. As a result a series of different types of plants was established. Some of these produced chemical compounds which would be further processed into finished explosives at another site, some carried on the whole manufacturing process, and some combined both, producing finished explosives, as well as chemical ingredients.

The factories were also established *ad hoc* over a number of years as demand for different products changed and new processes were developed. Mapping the flow lines of production of the different types of explosive through these factories is not therefore a straightforward task. The functioning and relationship between the various factories can best be examined by grouping them both chronologically, and in terms of the individual products produced (see Table 4.1).

The key finished products produced were: cordite, used as a propellant, (with its precursor products nitro-glycerine and guncotton); the high explosive shell fillings Lyddite and TNT; the additive ammonium nitrate, used to make amatol and ammonal; and the fuse filling explosive tetryl, manufactured in smaller quantities. A range of other specialist explosives and fuse fillings was also manufactured.

The precise chemistry of these production processes is highly complex but, put simply, nearly all of the explosives described here were produced by the 'nitration' or treatment of a base product with varying concentrations of nitric and sulphuric acids.[76] As a result, facilities for the production of acid in large quantities were a feature of many sites, either as stand-alone plants, or incorporated into larger factories.

Cordite

Cordite was used as the principal propellant for guns of all calibres. It is produced by the combination of two other high explosive compounds, nitro-glycerine (NG) produced by the nitration of glycerol, and guncotton also known as nitro-cellulose (NC) produced by the nitration of pulped cotton waste. Other products including acetone and mineral jelly are also required during the manufacturing process. Prior to 1914, government production of cordite was chiefly carried out at the Royal Gunpowder Factory Waltham Abbey, which produced approximately one third of the annual requirement, the rest being purchased from private manufacturers.

Production was significantly expanded at Waltham Abbey during the war, and in 1914 a second factory was established to meet the needs of the Royal Navy for cordite. This was the Royal Naval Cordite Factory (RNCF) at Holton Heath

in Dorset.[77] Both of these sites have been subject to previous separate studies.[78] Specific changes to the Waltham Abbey site during 1914-1918 have been described in section 4.1. As a Naval site rather than a National Factory details of operations at Holton Heath fall outside the scope of this report. A third very large factory for the production of cordite was established in May 1915 at Gretna, straddling the Anglo-Scottish border. By 1917 this plant was producing between 800 and 1000 tons of cordite per week.[79] Guncotton was also manufactured in a factory at Colnbrook, Middlesex initially leased from the Belgian Government then later nationalised in 1916.

Wood Distillation and Acetone

Acetone was a key ingredient in the manufacture of cordite. The Government had set up a plant at Coleford in the Forest of Dean, Gloucestershire in 1913 to produce acetone by distillation from wood. In 1915 with the increase in demand for the product, new Government factories were established at Bideford and Dundee. In 1917 a further factory at Longparish in Hampshire formerly managed by Kynoch's, a private arms manufacturer, was taken over, and in 1918 construction was begun at three further sites at Carmarthen, Ludlow, and Mid Lavant near Chichester. However hostilities ceased before these latter factories could come into production.[80]

Cotton Waste

Cotton was a key source of cellulose for the manufacture of nitrocellulose/guncotton and thence cordite. This cotton was sourced as waste from the cotton mills of the textile industry in the north of England. Until 1917 this trade was almost wholly controlled by the 'British and Foreign Supply Association' who owned a number of mills in the region. In 1917 the Government bought out the Association and took its mills under direct control. Eight mills were ultimately designated as 'HM Cotton Waste Mills', at Bury, Charlesworth, Greenfield, Hadfield, Oldham, Rawtenstall, Whaley Bridge, and Woodley.[81]

Lyddite

Lyddite, also known as picric acid was the principal high explosive shell filling used by the British Army and Navy prior to 1914. Its use was gradually eclipsed by that of TNT, but it continued to be an important explosive throughout the war. It is produced by the nitration of phenol (carbolic acid) into tri-nitro-phenol (TNP).[82] Phenol was initially derived from coal tar, but later also produced synthetically. At the start of the war all lyddite production was in private hands including Nobel's. A plant was put at the Government's disposal in 1914 at West Gorton, Manchester, for the synthesis of phenol, but this was initially not highly productive. In February 1915, a contract was entered into by the Government with the United Kingdom Chemical Products Co. to produce phenol at Sutton Oak near St Helen's. This plant was taken over fully by the Ministry of Munitions in January 1916.[83] A further plant was also constructed in March 1916 at Ellesmere Port, adjacent to the Manchester Ship Canal, producing synthetic phenol by synthesis from benzene, although in 1918 both these plants were converted to production of ingredients for poison gas (see Section 4.7).[84]

Initially the finished explosive continued to be produced under contract with commercial firms, but by 1916 this was found to be inadequate. A National Factory for the production of finished picric acid was established at Avonmouth in the summer of 1916 (although this too was converted to poison gas production in 1918), and this was followed in December 1916 by the establishment of three more factories at Bradley in Yorkshire, Greetland near Halifax, and Lytham in Lancashire. These were initially under agency management but were later taken under direct Government control.

Tri-nitro-toluene (TNT)

Tri-nitro-toluene, or TNT, also sometimes referred to as trotyl is produced by the nitration of toluene, (also known as toluol). Toluene is derived from hydrocarbon oil, or like phenol from coal and coke. TNT had been adopted by the Germans as their principal shell filling as early as 1902, but it was initially rejected in the UK due to its inferior explosive power relative to Lyddite, and the difficulty of detonation. It was found, however, that not only was it cheaper to produce than Lyddite, but its low melting point made shell filling with melted TNT simpler and safer.[85] As the war progressed both pure TNT, and its use as an ingredient of amatol and ammonal, greatly increased.

The demand for TNT was immediately recognised in 1914 and the first National Factory was established at Oldbury, Worcestershire, in December 1914. This was supplied with chemical by a plant for distilling toluene from petroleum, brought from Rotterdam by the Asiatic Petroleum Co. and set up at Portishead near Bristol. Subsequently in 1915 further TNT production sites were established at Queensferry and Sandycroft, near Chester, and Barrow, and an additional toluene refinery was built at Trafford Park, Manchester. Further factories were also taken over for TNT production during 1915-16 at Hackney Wick, London, and Litherland near Liverpool.[86] A factory for refining crude TNT was also constructed in 1916 at Gadbrook near Northwich, Cheshire.[87] This complemented an existing TNT purifying plant at Rainham near Woolwich. TNT was also produced at plants at Craigleith in Scotland and Pembrey and Penrhyndeudraeth in Wales.

Amatol and Ammonal

Used as a shell filling, pure TNT remained relatively expensive, and supplies of toluene were limited, but it could be made to go further by mixing with varying amounts of ammonium nitrate, a much cheaper compound commonly used as agricultural fertiliser. Up to 80% ammonium nitrate was used effectively in a mixture known as amatol. Despite problems due to the fact that the ammonium nitrate did not melt like TNT and could thus not be poured into shell casings, amatol became a standard shell filling.[88] This mixture was produced at HM Explosives Factories, but the two ingredients were also mixed on site at Shell Filling Factories.

In addition a mix was produced of ammonium nitrate, aluminium powder and TNT, known as ammonal. This was more commonly used as a blasting explosive for engineering and mining works. Almost one million pounds of ammonal was used in

the series of mines blown under German positions at Messines Ridge in Belgium in June 1917.[89] Much of the required ammonium nitrate for both these explosives was produced commercially, in particular by Brunner Mond & Co. but a National Factory for its manufacture was also constructed at Stratton near Swindon in 1917.[90] Calcium nitrate, from which ammonium nitrate could be manufactured was also produced in the National Factory at Victoria Works in Northwich. Finished amatol and ammonal were both produced at a National Factory established in 1915 at Watford.

Tetryl

Tetryl, or 'Composition Exploding' (CE) is produced by the nitration of aniline, another coal tar derivative. It is a powerful but sensitive explosive not suitable for shell filling. However it was widely used as an exploder for more stable explosive fillings such as TNT and amatol. As such only relatively small quantities of tetryl were required. This was produced in a plant at Waltham Abbey, and latterly in a similar facility at Queensferry.[91]

Raw Material	Intermediate Product	Finished Product
Cordite		
Cotton Waste Bury (1917) Charlesworth (1917) Greenfield (1917) Hadfield (1917) Oldham (1917) Rawtenstall (1917) Whaley Bridge (1917) Woodley (1917)	Guncotton Waltham Abbey (1914) Holton Heath (1914) (Gretna) (1915) Colnbrook (1916)	Cordite Waltham Abbey (1914) Holton Heath (1914) (Gretna) (1915)
Acetone Coleford (1913) Bideford (1915) (Dundee) (1915) Longparish (1917) Ludlow (1918) Mid-Lavant (1918) Kings Lynn (1918) (Carmarthen) (1918)	Nitro-Glycerine Waltham Abbey (1914) Holton Heath (Gretna)	
TNT		
Toluol Rainham (1914) Portishead (Dec 14) Trafford Park (Oct 1915)	MNT Oldbury (Dec 1914) Sandycroft (1915)	TNT Gadbrook (1915) (Penrhyn Deudraeth) (June 1915) Hackney Wick (July1915) Litherland (July1915) West Gorton (from 1915) (Pembrey) (Oct 1915) (Craigleith) (April 1916)
Amatol/Ammonal		
Ammonium Nitrate Victoria (Oct 1916) Langwith (Nov1915) Swindon (1917)		Ammonal Watford
Lyddite/Picric Acid		
Phenol West Gorton (1914) Sutton Oak (July 1915) Ellesmere Port (Oct 1915)		Picric Acid Avonmouth (1916) Bradley (Late 1916) Greetland (Late 1916) Lytham (Late 1916)
Tetryl		
		Tetryl Waltham Abbey (1914) Queensferry (1915)

Table 4.1 Output of H M Explosives Factories, 1914-1918.

(Factories in Wales and Scotland are indicated by parentheses).

Factory Characteristics

Almost nothing of the infrastructure of the 26 HM Explosives Factories in England survives to the present. In nearly all cases the sites have been demolished and redeveloped. This reflects the fact that often these were complex chemical works whose buildings could not easily be adapted to new functions, and in addition they were often contaminated by the products they manufactured, making re-use hazardous and demolition and decontamination a preferred option. Only the cordite incorporation and pressing buildings, and a few small stores buildings at Waltham Abbey, (discussed in an earlier section, pp 44-46) and some magazine and stores buildings at Gretna and Swindon survive from this substantial industry.

The diversity of functions among the HM Explosives Factories already outlined makes it difficult to generalise concerning their construction and layout. However most required substantial brick and concrete structures where industrial-scale chemical processes could be carried out. Typically individual processes would be contained within separate buildings, and these would then be surrounded by ancillary buildings occupied by offices, boilers, canteens and other functions.

Cordite

The surviving cordite processing buildings at Waltham Abbey have been described in the previous section. It was clear immediately in 1914 that production would have to be increased beyond the capabilities of the RGPF site, and there was also competition between the Navy and the Army for any additional output which might be achieved. Since January 1914 the Royal Navy had already been developing what was to become the Royal Naval Cordite Factory (RNCF) at Holton Heath in Dorset.[92] In May 1915 increased capacity to meet the needs of the Army was recommended by the Munitions of War Committee. It was decided that an additional 2,000 tons of propellant was required monthly and that if practicable this could all be made in one large factory.

A location for this factory was determined upon, straddling the English/Scottish border at Gretna. Here it was far away from any German air threat, but was also conveniently located for rail links to the rest of the United Kingdom (Fig 4.5). The sites at Gretna were acquired in July 1915. The different manufacturing processes were spread out over a wide area. Near Dornock in the west, a low lying area of flat countryside on the north side of the Solway Firth was used to establish acid factories, a glycerine refinery, and guncotton and nitro-glycerine plants. Most of these features were demolished rapidly after the war, when the site was converted into an Army storage depot, but two guncotton drying stoves still stand, and the footprints of the other buildings of the guncotton drying facility can be seen on aerial photographs (Fig 4.6).

On the English side of the border to the east, a large rectangular site was laid out to accommodate eight ranges of cordite processing buildings. This site too was later converted to an Army ordnance store and most of the original buildings have been demolished. To the north-east, however, at Smalmstown was a further compound

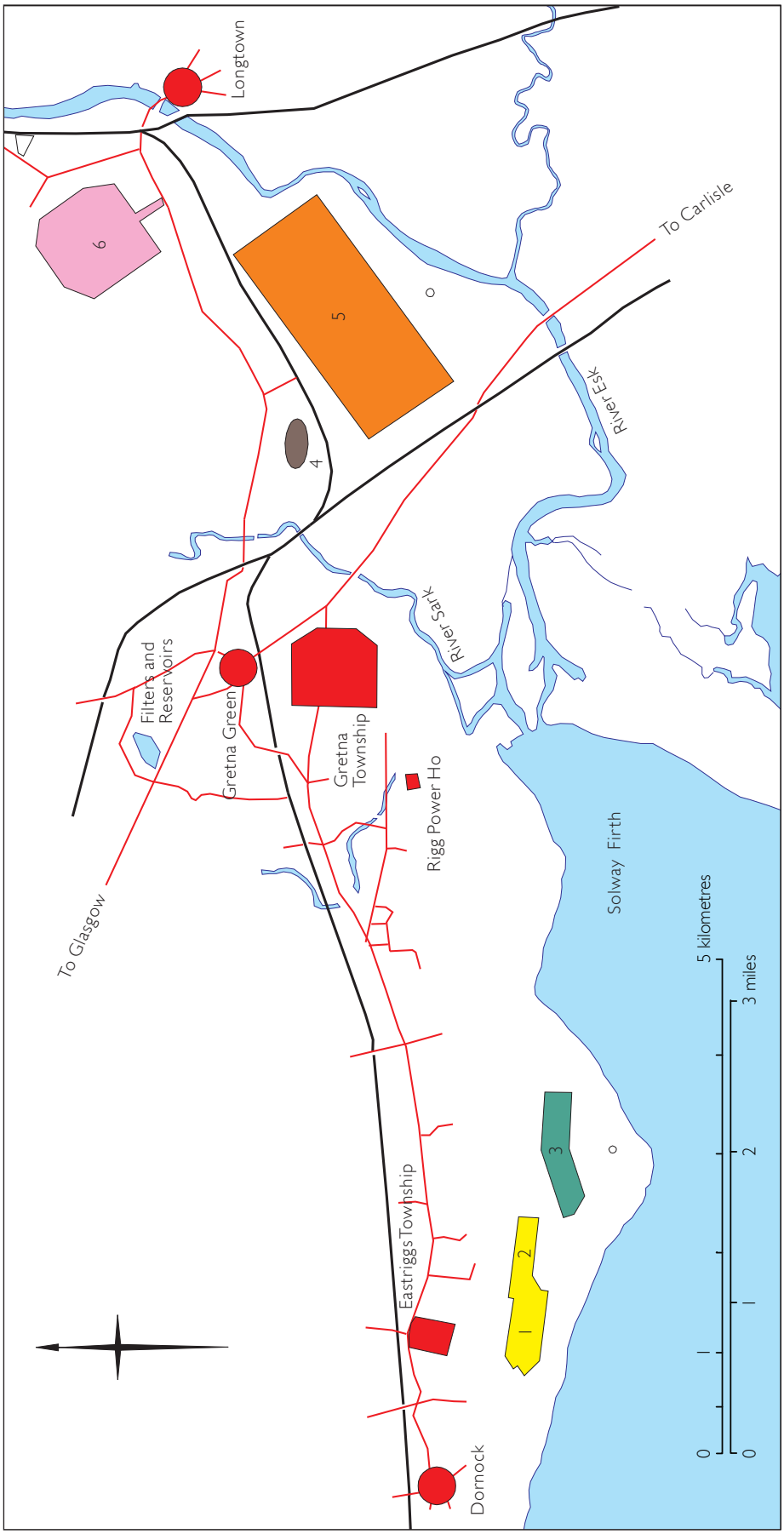


Fig. 4.5. HMEF Gretna, site plan showing various production areas (redrawn from TNA SUPPLY10/15).

Fig. 4.6. HMEF Gretna, Quinan guncotton drying stoves, 1995 (W Cocroft).

used as a magazine for finished propellant (Fig 4.7). This site consisted of a series of brick storage buildings linked by railway lines and protected by L-shaped bunds on their north and west sides. This site was also re-used by the MoD, but it would appear that the existing buildings were retained, and at least some of the protective earth bunds also survive, although the railway lines have recently been lifted.

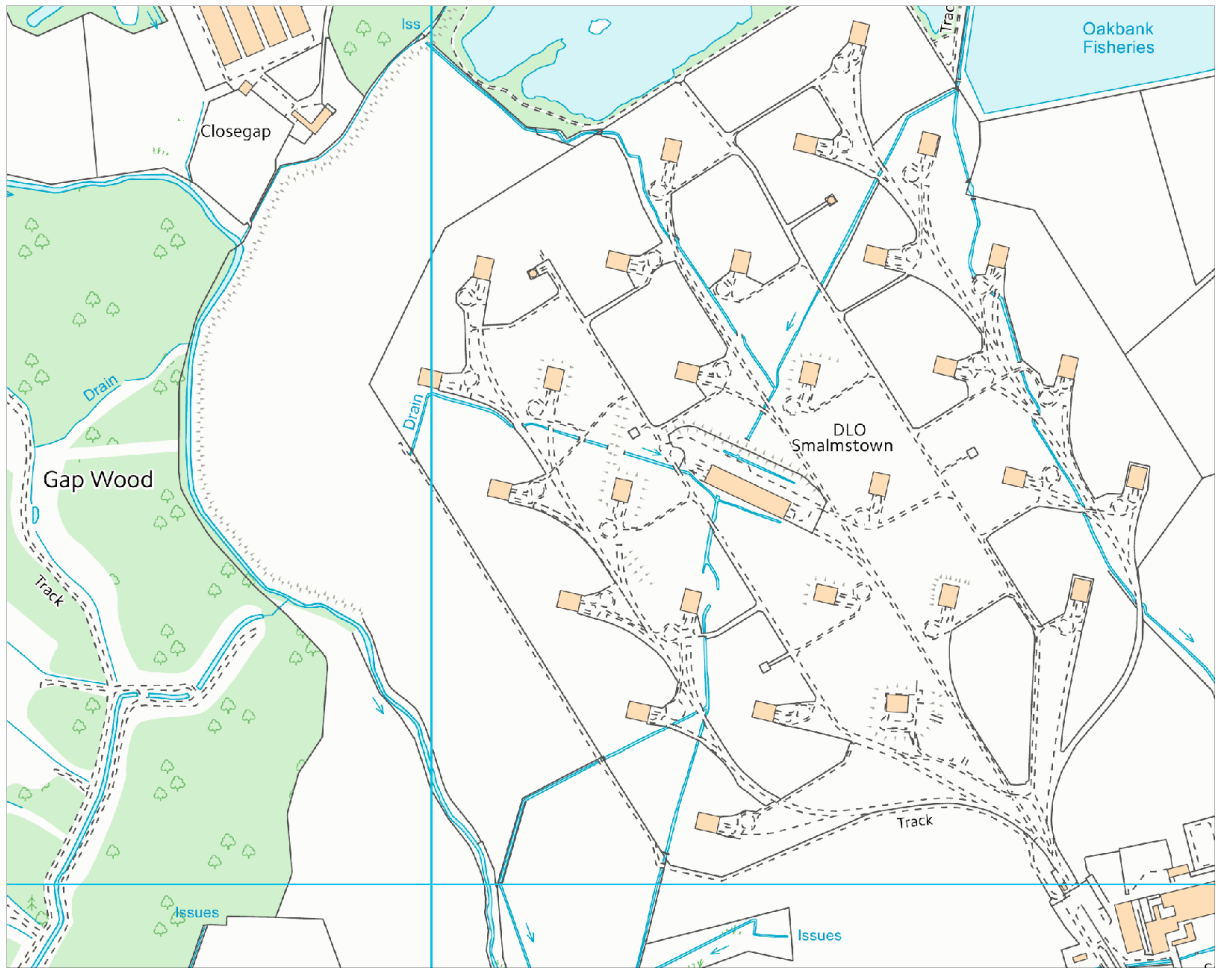
Cotton Waste Mills

The Cotton Waste Mills were a key part of the production chain for nitro-cellulose/ guncotton, and hence cordite, but they form a separate group in terms of their physical character. These mills were already functioning under the auspices of the British and Foreign Supply Association before they were nationalised, and all were housed in pre-existing cotton mills. Most of these were of 19th-century construction and received little alteration for their wartime role. Their appearance was therefore typical of the cotton industry buildings of the north of England: large, often multi-storey brick or stone-built structures, typically associated with leats for the use of water power, albeit by 1917 many also had steam boilers and other power sources. Several of these survive (see Appendix B), but there is little remaining to show their specifically wartime function.

Wood Distillation and Acetone Factories

This last group of factories which were part of the cordite production network were generally smaller concerns. Each factory was intended to produce around 400-500 tons of acetone per year, and the total number of employees at four factories (Bideford, Coleford, Dundee and Longparish) was only 600.[93] As a result it has been

© HISTORIC ENGLAND



Modern Ordnance Survey mapping: © Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900. Historic Ordnance Survey mapping: © and database right Crown Copyright and Landmark Information Group Ltd (All rights reserved 2015) Licence numbers 000394 and TP0024. Marine mapping: © British Crown and SeaZone Solutions Ltd 2015. All rights reserved. Product licence number 102006.006. © Historic England.
This image is indicative and for internal use. It does not necessarily represent the extent of any development proposals and/or heritage assets and may be subject to distortions with measurements scaled from this map not matching measurements between corresponding indicators on the ground. It is not to be taken as a representation of any Historic England assessment.

Fig. 4.7 HMEF Gretna; Surviving Magazine buildings at Smalmstown (OS 1:25,000 map).

difficult to locate the exact sites of some of these factories (see Appendix A). Where plans and surviving buildings have been identified (for example at Ludlow, see Appendix B) these typically comprise simple single-bay sheds. The most distinctive feature of these sites during their period of operation would have been the large stockpiles of wood stored around each factory. Correspondence concerning the disposal of this wood during the 1920s survives in The National Archives. The Bideford site, for example, is described as having 4-5,000 tons of wood stored at the plant.[94]

Tri-nitro-toluene (TNT)

A significant number of the sites taken up for the production of TNT and its precursors were based on existing chemical works and *ad hoc* expansion of production led to crowded and awkwardly laid-out factories. The difficulties resulting from this were described in a post-war report on the phenol and TNT factory at West Gorton near Manchester.

> The buildings in which the above processes were carried on were for the most part defective in design and shoddy in construction. The offices, stores and workshops were for the most part converted dwelling houses and very ill-adapted for such purpose. The general congestion and bad layout rendered the introduction of improvements and extensions exceedingly difficult and expensive. [95]

Similarly the factory at HMEF Hackney Wick was based upon the existing Phoenix Chemical Works on White Post Lane in Hackney Wick, an otherwise crowded residential district. This led to the decision to close the factory in April 1917, although it was kept in a condition to be re-opened if required.[96] This decision may well have reflected fears created by the catastrophic explosion in January 1917 at the nearby Brunner Mond TNT plant at Silvertown.[97] Brunner Mond also opened a purpose-built TNT plant in 1915 at Gadbrook, near their other chemical operations in Northwich. This factory was built on a greenfield site away from residential areas. However the Gadbrook works were taken over by the Ministry in 1917, principally in response to safety concerns following the Silvertown blast. All of these factories have been demolished and little information on their exact character has been identified.

Amatol and Ammonal

The construction of the ammonium nitrate plant at Stratton Works in Swindon was described at some length in an article in the *Journal of the Royal Institute of British Architects* in 1919 (Fig 4.8).[98] The factory was positioned next to an existing railway and 'The general lay-out of the buildings was planned with a view to rapid production and the saving of labour in handling materials'.[99] The site was entered via a courtyard which contained administrative buildings, canteens, and clocking-on and shifting rooms. This then gave access to the main factory site, at the core of which were three monumental brick crystalliser and evaporator houses. Stores for raw materials were placed adjacent, with an aerial ropeway leading to the south allowing waste sulphates to be removed and dumped. Overall the site was quite scientifically laid out with consideration of production flow and efficiency. This was

possible at Stratton since it was a newly-built factory, as opposed to the cramped and illogical production arrangements at some pre-existing explosives sites. The major production buildings on this site have been demolished but one stores building and a possible guardroom bungalow survive (see Appendix B).

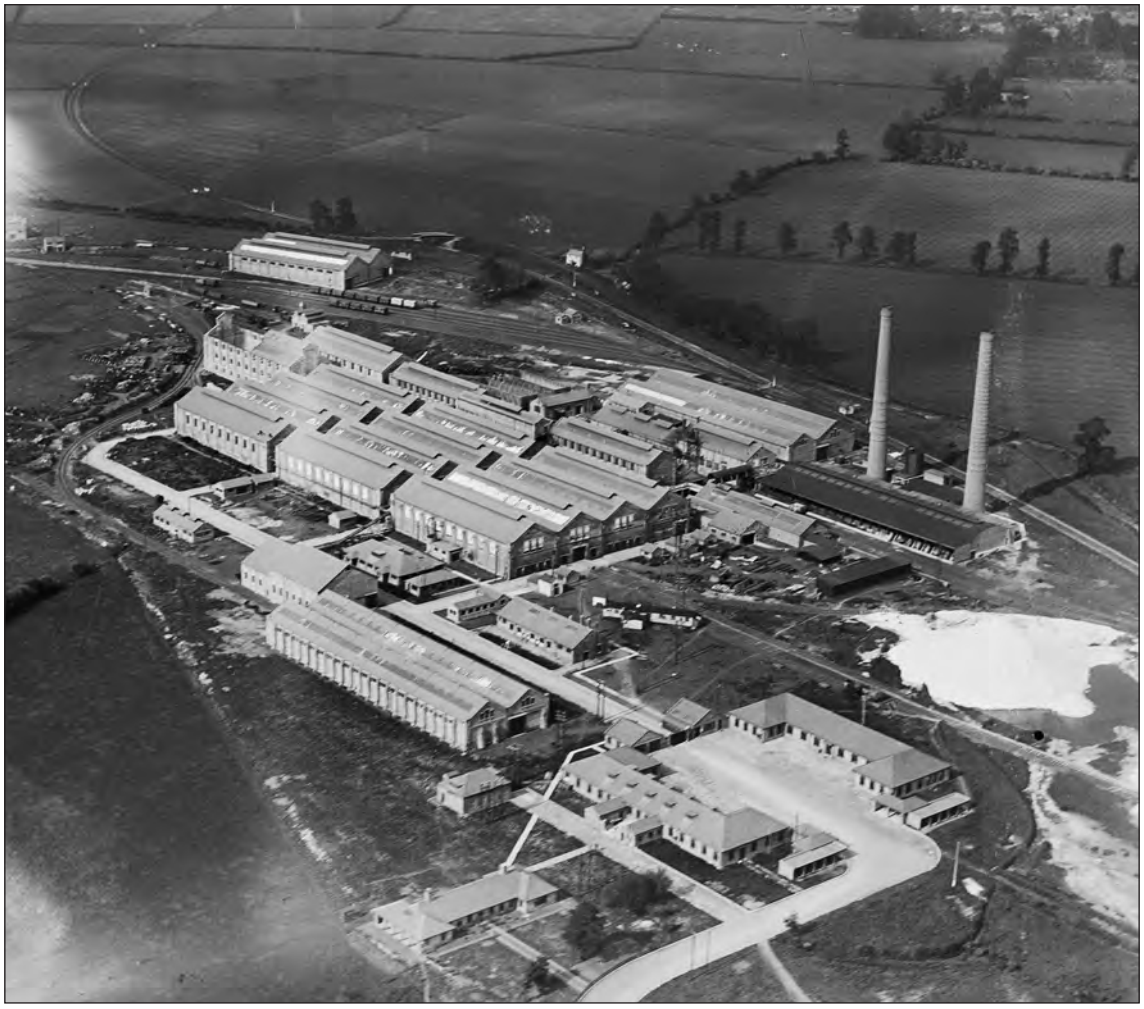


Fig. 4.8. HMEF Swindon (Stratton works), air photograph, 1920 (© Historic England EPW000941).

Lyddite/Picric Acid

As has been described, the demand for picric acid was very high in the early years of the war and tended to decline as TNT took over as a preferred bursting charge for shells of all calibres. Initially the production of the final explosive was left to private firms and it was the production of precursor chemicals such as phenol which attracted government attention. HMEF West Gorton was taken under government control in 1914, but was later switched increasingly to TNT production. Phenol was also produced under government control after 1916 from HMEF Ellesmere Port and at HMEF Sutton Oak (Fig 4.9).

Both these factories were later converted to the production of arsenic-based chemical weapons compounds. These particular chemical agents were never used

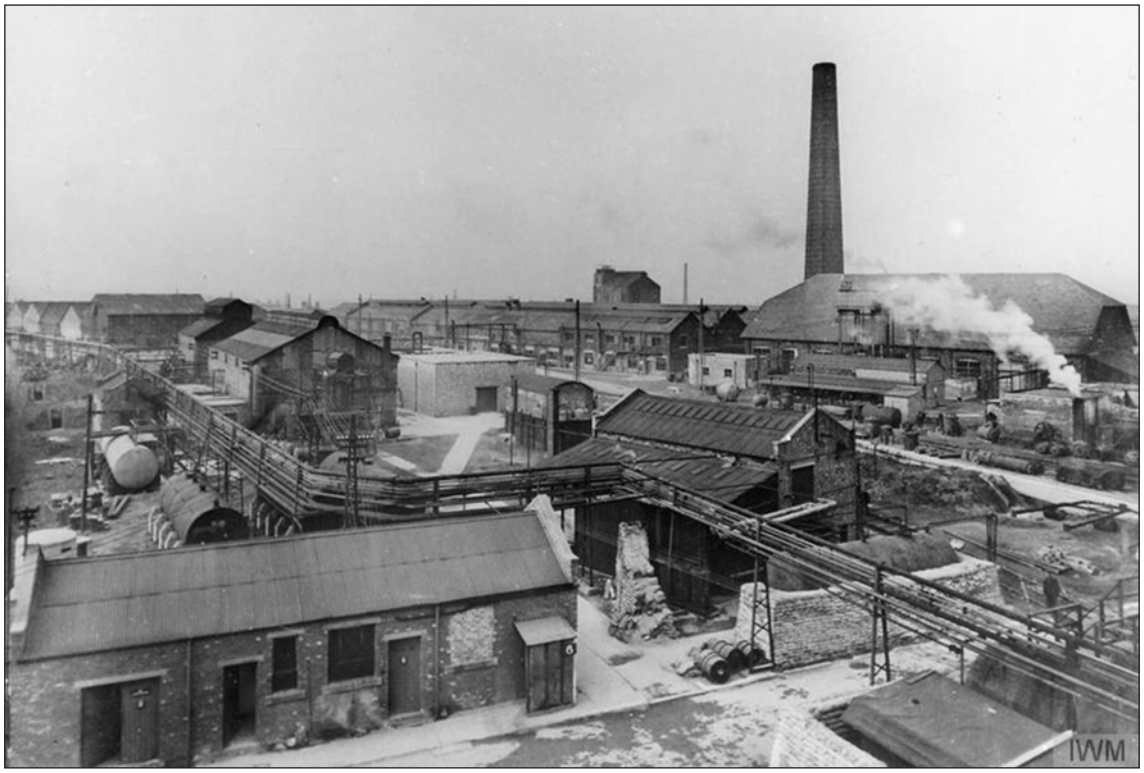


Fig. 4.9. HMEF Sutton Oak, undated (possibly Second World War) photograph of factory (© IWM HU 102403).

in anger, however, as the Armistice was signed before either factory could produce sufficient quantities for deployment to the battle front. In the case of Sutton Oak, the production of chemical weapons became the post-war raison-d'être of the site, and mustard gas and other agents continued to be developed and stockpiled there until the 1950s. The site was ultimately re-named the Sutton Oak Chemical Defence Research Establishment. It was finally demolished in 1957.[100]

For the manufacturing of the completed explosive a national factory was constructed from scratch in 1916 at HMEF Avonmouth (Fig 4.10). This factory was constructed for the manufacture of sulphuric acid for supply to other factories, and for production of finished picric acid explosive itself. A site was selected in the existing industrial area near Avonmouth docks, which provided rail links to the Great Western Railway. A series of five parallel production units was established, with a view to producing up to 350 tons of picric acid per week. [101]

One feature of this factory was that, in addition to the strictly functional construction of the process buildings, some architectural effort was also expended on the other parts of the site. A large and relatively ornate brick office building was constructed on the western side of the site (Fig 4.11). This has since been demolished. This indicates that while wartime economy and efficiency were clearly important, aesthetic factors were not completely forgotten, and given the enormous scale of construction at sites such as this the inclusion of modest architectural adornments probably did not add greatly to costs and construction times.

Fig. 4.10. HMEF Avonmouth, air photograph, 1927 (© Historic England EPW019264).

Fig. 4.11. HMEF Avonmouth, former office building, 1997 (© Historic England BB97/117).

No finished explosive was produced at Avonmouth as before the construction could be completed widespread use of Lyddite had declined. The oleum (fuming sulphuric acid) plant did continue in production, supplying TNT factories with acid, particularly that at Pembrey in Wales. In 1918 the redundant parts of the plant were taken over for mustard gas (HS) production, as it was decided to separate the filling of HS shells, carried out at nearby Chittening, from the manufacture of the agent itself.

Avonmouth was initially intended to be the single national factory for picric acid, but in December 1916 it was decided to establish a further three, at Bradley, Greetland and Lytham. A photograph survives of the picric acid works at Greetland, near Halifax. The location of this factory was specially chosen for its good rail links, and in particular the fact that the railways ran on an embankment which served both to contain any explosion within the site, but also allowed acids to be unloaded by gravity from railway tankers. According to the official *History*; 'The layout was admirably planned for economy and efficiency, and the plant well designed and fitted'.[102] A distinctive feature of this factory is the use of piers rather than solid walls surrounding some of the plant, presumably to assist with ventilation and dispersal of fumes.

4.3 NATIONAL SHELL AND NATIONAL PROJECTILE FACTORIES (NSF AND NPF)

Purpose

The National Shell and National Projectile Factories were established to produce the metallic components of shells, principally by forging and lathe-turning steel billets provided from other factories. These empty casings would then be sent on to Filling Factories, to be filled with explosives and have fuses fitted, and in the case of 'QF' ammunition, to be assembled into a complete round by attachment to a filled brass cartridge.

In the spring of 1915, the need for additional shell production was acute, and throughout the country the owners of engineering concerns, large and small, formed themselves into local Munitions Committees with the intention of volunteering their capacity for shell-making. It was rapidly realised, however, that these companies would be best pooling their resources at large sites where their efforts could be properly co-ordinated. This is described in the official *History of the Ministry of Munitions* thus:

> They returned unanimously of the opinion that, in view of the difficulties as to machine tools, supervision and control the best method in a district was to select a suitable factory and concentrate tools, workmen, supervision, and inspection under one management on a non-profit basis.[103]

In order to regulate this process the Ministry of Munitions created a scheme whereby National Shell Factories would be established. In each case the local Committee would select a board of management who in turn would use their local knowledge to find suitable premises, machine tools, staff, etc. and this would be funded directly by the Ministry, to whom in turn the Board became accountable. By June 1915 17 such factories had been established.[104]

The National Shell Factories were initially concerned with the manufacture of smaller calibre munitions; 18pdr and 4.5-inch howitzer shells in particular. Larger calibres were produced by the existing armaments manufacturers, including large national firms such as Vickers and Cammel Laird. Production of these shells also needed to be expanded but the existing manufacturers were reluctant to allow this work to pass out of their control. Instead an agreement was reached that manufacturers would set up new factories linked to their existing production sites, which they would administer, but which were fully funded by the Ministry. A number of these factories were built, and these were known as National Projectile Factories. As the war progressed many Shell Factories took on work producing larger calibre shells so the distinction between NSF and NPF in terms of calibre of product ceased to exist, but the differences in management arrangements persisted.[105]

Factory Characteristics

A key difference between the shell and projectile factories was that of scale. Shell factories tended to be small concerns. While the largest of these, such as Leeds (Armley Road) NSF (which was established in the railway carriage shops of the Leeds Forge Company) employed over 3,500 people, this was the exception rather than the rule. Out of 29 factories where staff numbers are recorded, 20 employed fewer than 600 people. The smallest of all was the NSF established in the Corporation Electricity Works in Chester which employed 37 people (21 of them women) to operate 14 lathes. This tiny factory was nonetheless able to produce up to 1,000 18pdr shells per week.[106] Women employees were a significant proportion of the labour force in these factories, making up 72% on average. The proportion of women employees ranged from 40% in Bootle to 86% at Hartlepool.

National projectile factories by contrast were typically much larger. The biggest, at Lancaster, had over 8,500 employees, while the average was over 4,500. Women tended to be less well represented in the workforce at these sites. This was partly due to the fact that shell forging was considered to be men's work. At Sheffield (Tinsley) NSF, for example:

> At present no female labour is employed in the forge itself, nor is it probable that it will be in the future, at least in the forge proper. The heat here is somewhat trying, and it is believed that male labour alone is suitable.[107]

At Birtley NPF, meanwhile, the Belgian government administration of the factory permitted no female employees at all except in a few minor clerical roles.[108] More widely, however, in British administered factories, women were well represented in the turning and machining departments, which compensated for their absence from the forges to the extent that typically around 50% of the workforce at each factory was female.

National Shell Factories

The urgent need for premises meant that national shell factories were established in a wide variety of pre-existing buildings. More or less the only criterion was that there should be plenty of floor space for the installation of machines, and that the buildings should be freely available, either at cheap rents, or donated for the duration of the war (Fig 4.12). The diversity that resulted is described in the official *History*:

> Buildings of a totally unexpected character, as for example an old herring-curing factory, a malt-house, a toy factory, a roofed market, a rifle drill hall, served their turn as national shell factories. Railway engine sheds and repairing shops were successfully adapted, and the corporations of various towns also placed premises in their Tramways or Electricity Departments at the disposal of the local Board. [109]

The diversity of buildings used is shown on Table 4.2. Similarly, many factories were set up with machines either borrowed, bought, or hired locally and these were

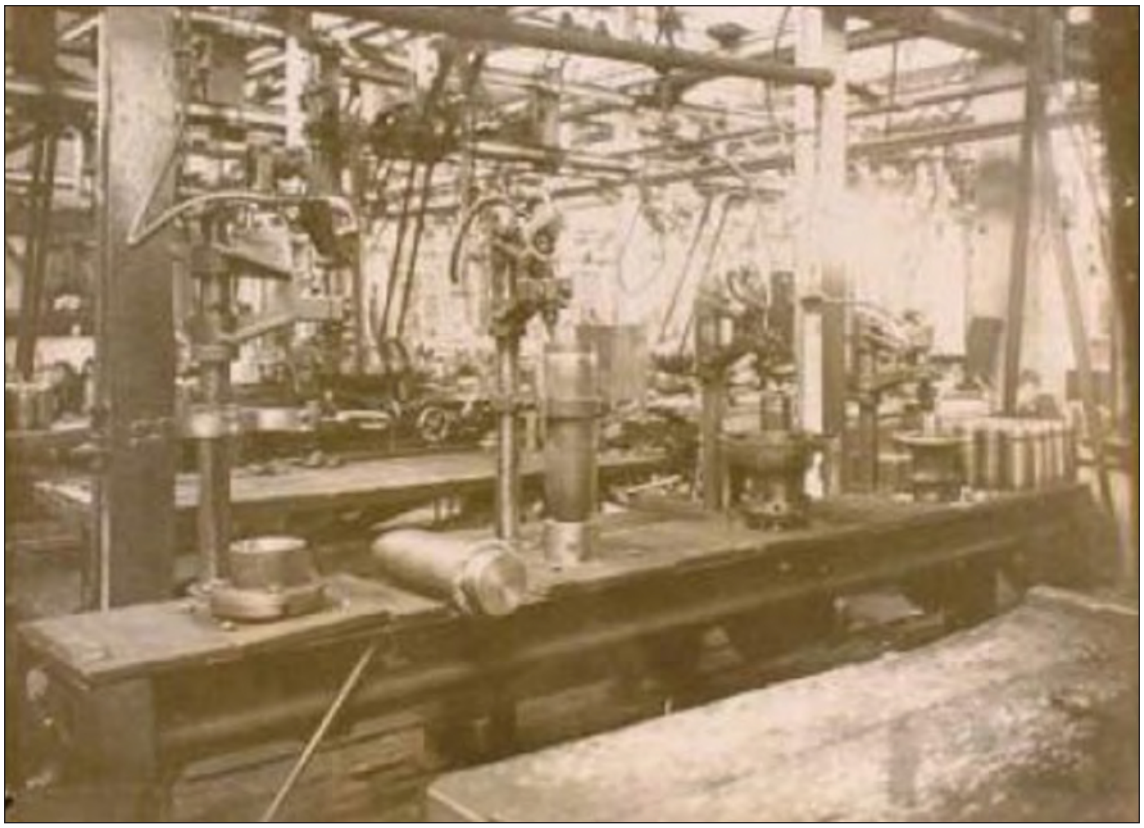


Fig. 4.12. NSF Liverpool (Haymarket), the crowded interior of the machine shop installed in the former covered produce market at 1916 (Liverpool Libraries).

highly variable, and in some cases in poor condition. Later the Ministry took on the supply of lathes and other machinery but this process was still subject to delays and shortages.[110]

An example of a building adapted in this way was the former Cunard ships' fittings store on Rimrose Road, Liverpool. This factory was taken over in June 1915. The existing machine tools were not appropriate for shell turning and so had to be adapted. To create additional space the building was extended, and an additional storey was built of concrete and steel girders. Initially the factory was to produce 4.5-inch shell but machines were also set up for 6-inch and 8-inch work.[111] Surviving images of the interior of this building show belt driven lathes, and overhead cranes, as well as the inserted mezzanine floor (see Fig. 4.13). Rimrose Road had the distinction of producing the first 8-inch shell made by female labour. This shell was preserved in order to be exhibited, and now forms part of the collection of the Imperial War Museum.[112]

In some cases it was not possible simply to requisition one building of suitable size and several were used together. An example of this was East Cumberland NSF in Carlisle. Here a series of buildings was taken over along Strand Road. The main machine shop was established in the Rifle Volunteer Drill Hall which, as its name implies, had a large roof-lit hall at the rear. A few doors to the west, the Territorial Army Drill Hall was taken over as stores, while to the east a Church Mission Hall was adopted as a works canteen. Several intervening houses between the drill

Fig. 4.13. NSF Liverpool (Cunard), women workers in Rimrose Road turning large calibre (8-inch) shells 1917 (© Historic England BL/24001/09).

hall and the mission hall were also taken over as offices. In October 1918 this site employed around 250 people, of whom 209 were women, and was capable of producing 4,000 18pdr shells per week despite its unlikely surroundings.[113]

Factories were also 'Nationalised' for other less philanthropic reasons. The Ailsa Craig Motor Company of Chiswick was an existing engineering company which was contracted in September 1915 to produce 4.5-inch shells for the local Munitions Committee while remaining a private company, a not uncommon practice. However when the company continued to demand payments in advance on the contract and no shells were forthcoming, and with legal suits looming, the Defence of the Realm Act was invoked and the factory was 'Nationalised' and placed under the compulsory management of the Metropolitan Munitions Committee as Metropolitan (Ailsa Craig) NSF [114]

Another building type which was particularly popular as a setting for National Shell Factories was the tram depot. Four factories were established in these buildings in Bury, Manchester, Liverpool and Rochdale. It is not clear where the trams were accommodated during this process, but the buildings lent themselves well to the purpose having large open floor areas, and in many cases presumably a minimum amount of engineering infrastructure in place already.

Existing Engineering Works	
Barnsley No. 1	
Barnsley No. 2	
Bradford	
Bristol	(Foundry)
Derby	(Foundry)
Hartlepool	(Marine engine works)
Huddersfield	
Keighley No. 1	
Keighley No. 2	
Leeds (Hunslet)	
Leeds (Armley Road, Wellington, and Sweet Streets)	
Liverpool (Edge Lane)	
Liverpool (Bootle)	
Metropolitan (Ailsa Craig)	(Motor works)
Metropolitan (College Park)	
Nottingham	(Lace factory)
Rotherham	(Iron works)
West Cumberland (Workington)	(Foundry)
Railway Works	
Birmingham	(Midland Carriage Works)
Leeds (Armley Road)	(Leeds Forge Co. carriage shops)
Leeds (Newlay)	(Wheel works)
Tram sheds/Depots	
Bury	(Corporation depot)
Liverpool (Lambeth Road)	
Manchester	(Hyde Road depot)
Rochdale	(Municipal tram depot)
Other	
East Cumberland (Carlisle)	(Drill hall)
Grimsby	(Herring-curing factory)
Liverpool (Haymarket)	(Agricultural market)
Liverpool (Cunard)	(Cunard ships' fittings stores)
Liverpool (Chester)	(Electrical depot)
Rawtenstall and Bacup no. 1 & 2	(Mills)

Table 4.2 Premises adapted as National Shell Factories, 1915.

National Projectile Factories

Unlike the Shell Factories which were placed in *ad hoc* buildings, the National Projectile Factories were typically constructed from scratch on greenfield sites and attention was paid to production flows and ergonomic design. A detailed account of the work of a projectile factory was published in *The Engineer* in July 1916. The factory concerned was not named due to wartime security concerns but examination of the plans included in the article indicates that it was at Sheffield (Tinsley and Templeborough).[115] The following description is taken from that article.

Fig. 4.14 NPF Sheffield (Tinsley), shell forge at work, 1916. The furnaces can be seen to the rear left, with presses in the foreground. Both steel billets and finished shell blanks are stacked nearby (TNA MUN5/157).

The factory was divided across two sites, a forging shop adjacent to the Messrs. Firth steelworks at Tinsley, and a shell turning plant built about a mile to the north-east adjacent to Templeborough steelworks on land rented from Earl Fitzwilliam. The Tinsley site was supplied by rail with steel billets roughly 15 inches long and rectangular in section (Fig 4.14). These were heated white-hot in coal gas furnaces before being shaped into cylindrical shell blanks in hydraulic presses. The work was carried out in a long open steel-framed and glass-roofed shed. Furnaces and presses were arranged in two rows along the length of the building making the production flow laterally across the width of the factory. Billets entered on the west side were heated in the furnaces, and then passed to the presses, emerging fully shaped on the eastern side. After inspection for correct pressing, the shells were sent on to the Templeborough site by steam wagon (Fig 4.15). Although parts of Tinsley Steelworks still stand, the 1916 forging shop has been demolished.

© HISTORIC ENGLAND

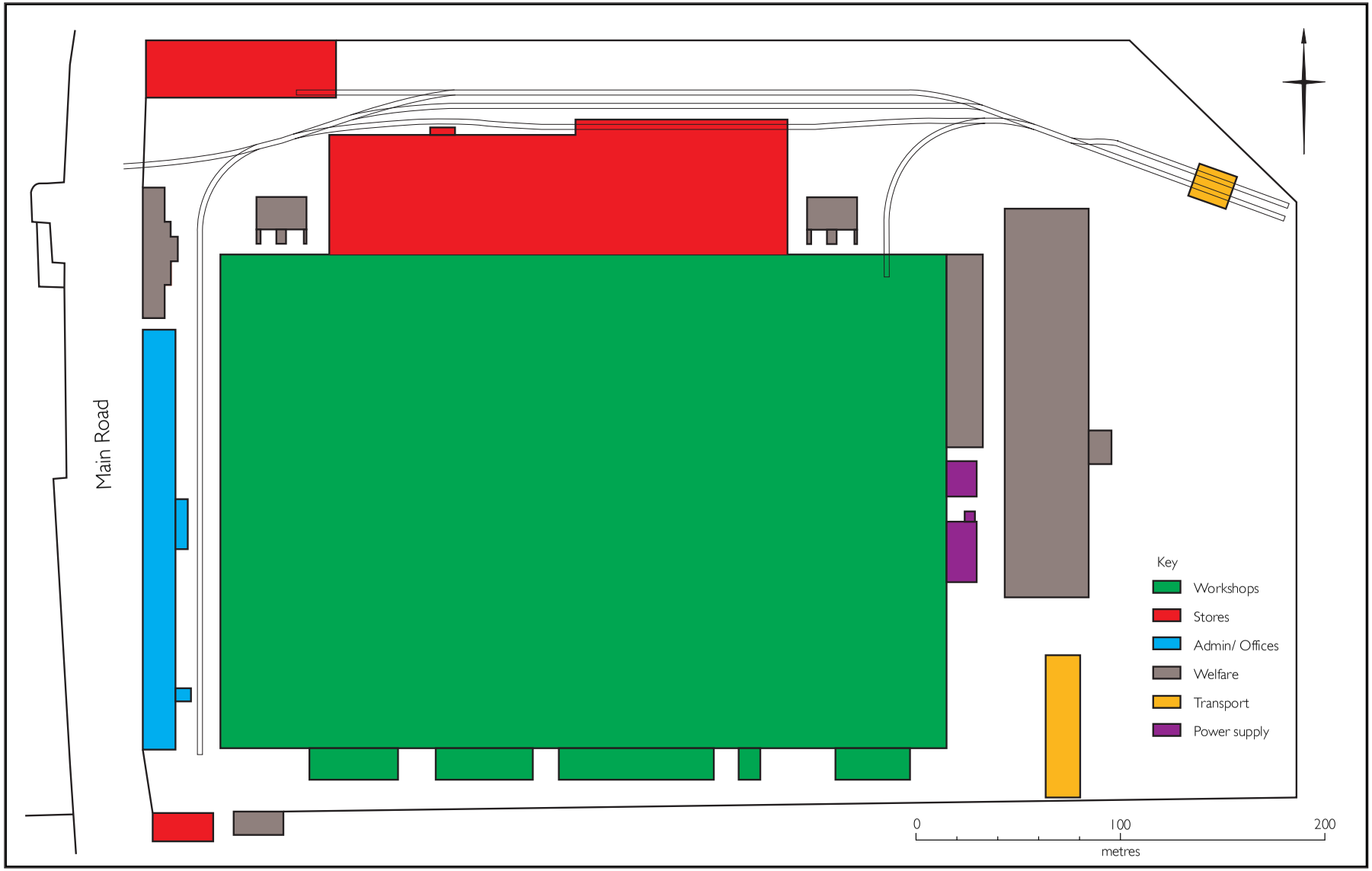


Fig. 4.15. NPF Sheffield (Templeborough), plan of the shell-turning shop, 1916. Steam wagons entered lower left, and production flow was from bottom to top of the plan with finished shells leaving by rail top left. (Redrawn from TNA MUN5/157).

On arrival at Templeborough, the process of turning the forged blanks into shells was carried out by a series of lathe operations. The account in *The Engineer* describes how the principle of 'dilution' was applied to the design of this factory. Instead of having a single general-purpose lathe capable of completing the 14 or so operations required to make each shell, 14 individually set up machines were provided on each production line, and shells passed from machine to machine and worker to worker. This allowed staff to be quickly trained. Most of these operations were performed by women.

Each bay of the factory building was essentially a separate production line (running from bottom to top on Fig. 4.15). Shell blanks were tipped off the steam wagons onto a sloping shelf which allowed them to roll through the western wall of the plant. Here they were collected and passed from lathe to lathe across the building, emerging complete on the east side. From there they were passed to asbestos-walled lacquering shops, each of which served a group of bays, where the shells were lacquered internally and painted, before being dried in gas-heated ovens.

Fig. 4.16. NPF Sheffield (Templeborough), interior showing shell-turning bays in operation, 1916 (TNA MUN5/157).

The process building itself was a simple open-plan shed, built of multiple bays of steel framing with steel uprights between the bays. These supported triangular roof trusses glazed on both sides. The individual machines were driven by belts connected to an overhead shaft which ran the length of each bay (Fig 4.16). These shafts in turn were powered by electric motors installed in the roof space. The external walls of the factory were formed of galvanised iron sheeting. In

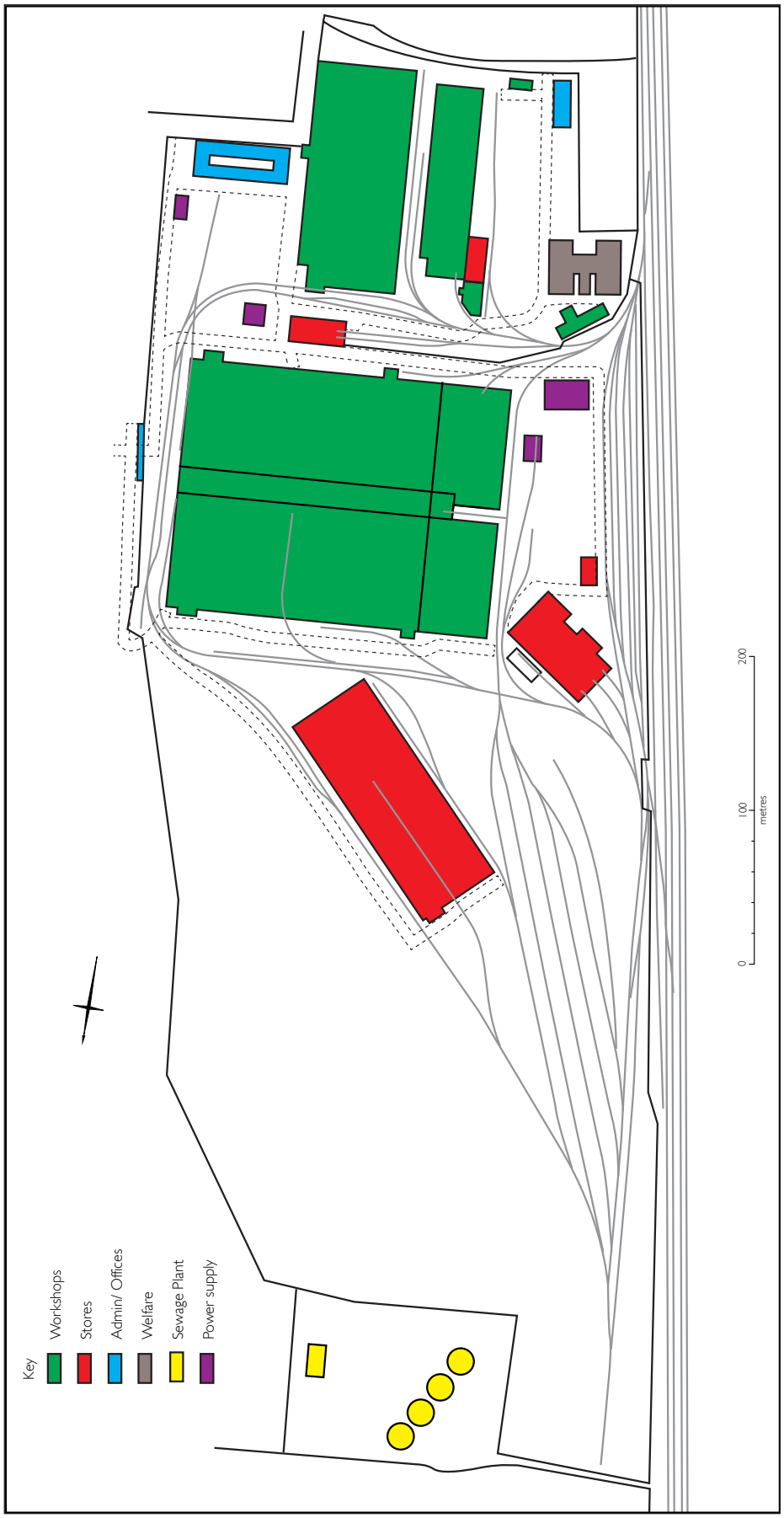


Fig. 4.17. N.P.F Birtley, plan, 1918 (redrawn from TNA MUN5/157).

addition to the main building, offices, latrines and other services were provided in single-storey buildings around the edges of the site, the offices in particular being built of thin concrete slabs mortared on edge and supported in steel U-section framing. A large canteen for the mostly female workforce was also constructed to the south of the main factory. All of these ancillary buildings have been demolished since 1918, but the western half of the main factory appears to be still standing with a new eastern wall (see Appendix B).

Another projectile factory for which substantial records survive is that at Birtley in County Durham.[116] A 52-acre site was selected by Messrs Armstrong Whitworth near the North Eastern Railway station at Birtley, and close to a colliery and electric power station (Fig 4.17). Construction was begun in July 1915. Two factories were built on the site, one for artillery shell, and one for small arms ammunition; however only the shell works was run as a National Factory. Surviving site plans show an arrangement similar to that at Sheffield, but both forging and turning were carried out at the one site, with two large forge buildings located at the western ends of a pair of machine shops. The northern of these two complexes produced 3.7-inch to 6-inch shells while the southern was devoted to 8-inch shells. In both cases finished shells were then loaded onto rail wagons at the east end of the plant before moving to a bond store to the north.

When completed the two machine shops were equipped with over 1,000 individual machine tools, including 966 lathes of all types. When fully operational this factory was capable of producing 18,000 shells of all calibres per week, and by the end of 1918 had produced over 2.8 million projectiles.

One of the unusual features of this factory was that the 3,700 employees were Belgian, having been recruited from the Belgian army and refugees in the UK. The factory was also administered by the Belgian Government. Unlike the Projectile Factories staffed by British employees, the Belgians eschewed female labour, and in October 1918 no women were employed in the factory. These workers and their families were housed in a specially built village known as 'Elizabethville' (see section 3). The plant was closed down at the Armistice and the Belgian workers were repatriated, but the factory buildings remained, and the two forges, as well as the southern (8-inch) machine shop, and other buildings including a canteen and several transformer buildings, survive on the site (see Appendix B).

Another National Projectile Factory that survives substantially intact is that built by A Harper, Sons and Bean Ltd at Waddams Pool in Dudley (see Appendix B).[117] This factory also included both forging and turning on one site, but whereas other factories could be constructed on level sites using simple steel-framed buildings with galvanised sheet cladding, the site acquired at Dudley was on a slope. As a result a more substantial multi-story brick factory was constructed. This factory was used by A Harper, Sons and Bean Ltd to produce cars immediately after the war before becoming the Marx toy factory in 1927.[118]

The atmosphere and working conditions in these factories, and particularly in the forges is depicted in a painting of the Hackney Marshes factory produced by

the artist Anna Airy, who was commissioned in 1918 by the recently established Imperial War Museum to paint life in the works. The extreme heat of the working environment is well captured by the painting (Fig 4.18). Airy's shoes reputedly became scorched during the painting process due to the residual heat of the floor of the shop.[119]

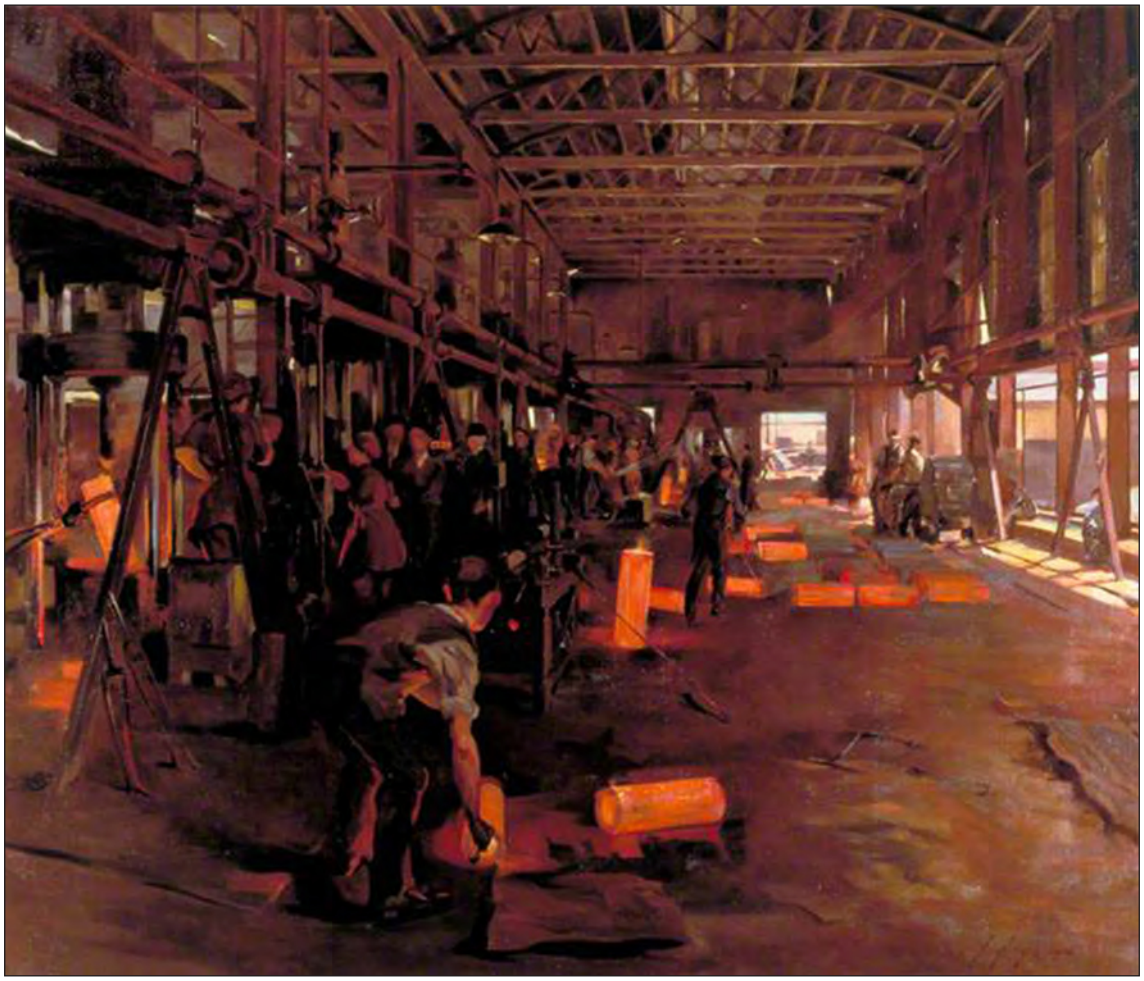


Fig. 4.18. NPF Hackney Marshes, shell forging in a painting by Anna Airy, 1918 (© IWM Art. IWM ART 4032).

4.4 NATIONAL FILLING FACTORIES (NFF)

Purpose

The National Filling Factories were established for the filling of shell casings with their explosive components, attachment of fuses and gaines (an intermediate explosive used to help initiate the main explosive charge), and for assembling 'QF' ammunition (artillery rounds such as the 18pdr where the shell was factory-fixed to a brass cartridge case). Prior to the war these functions had all been carried out by the Royal Laboratory at Woolwich. Five civilian firms did have capacity for shell-filling, and some had fulfilled contracts during the Boer War (1899-1902), but none was in production in 1914. In July 1915 the same shell shortage which had led to the establishment of the National Shell and National Projectile Factories, led to the consideration of expanding capacity for filling, to keep pace with the new potential for empty-shell manufacture.[120]

A meeting was held between the Ministry of Munitions and the various armament firms to solve the problem. A series of factories was proposed, some under direct Ministry control, and others run by local Boards of Management. The work of these factories was initially divided, as shown in Table 4.4, between filling of artillery shells; National Filling Factories' work on smaller trench warfare stores (grenades and mortar rounds); Trench Warfare Filling Factories, and chemical filling, which included not only poisonous gasses but also smoke and pyrotechnic rounds such as flares. The filling of artillery shells was also further subdivided between the smaller calibre field artillery shells, which contained a relatively small amount of explosive, and the more dangerous large calibre HE shells. Separate factories were also established for the manufacture and filling of fuses and other smaller explosive components.[121]

A further distinction between the various types of filling factory was also created by the methods required for physically putting the various explosives into the shell cases. Picric acid (lyddite) had the advantage that it could be warmed and melted, and then easily poured into shell casings. TNT could similarly be melted, however it was costly to produce and it was increasingly used in a mix with ammonium nitrate as amatol. High TNT content amatol, with a ratio of 60% TNT could still be melted and poured, but the preferred mix of only 20% TNT did not melt satisfactorily and had to be filled by pressing in powder form, by screw-filling as a paste, or by making pre-formed blocks of explosive the same size as the shell interiors.[122]

Purpose	Factory, and date of establishment
National Filling Factory (NFF)	
Filling and assembling QF ammunition (13pdr, 18pdr and 4.5-inch) shrapnel and high explosive (HE)	No. 1 Leeds (Apr 1916) No. 2 Liverpool (Jan 1916) No. 4 Georgetown (Jan 1916) Scotland No. 5 Gloucester (Mar 1916)
Filling heavy HE shell (4.7-inch and above)	No. 6 Chilwell (Feb 1916) No. 9 Banbury (Apr 1916) No. 18 Pembrey (Jul 1915) Wales No. 13 Morecambe (July 1916) No. 14 Hereford (Nov 1916)
Ammunition component manufacture (fuses, Gaines etc.)	No. 3 Perivale (Dec 1915) No. 7 Hayes (Oct 1915) No. 8 Southwark (Oct 1915) No. 10 Coventry (Mar 1916) No. 11 Abbey Wood (Jan 1916) No. 12 Cardonald (Jan 1916) Scotland National Fuse Factory Luton (Summer 1917)
Filling Naval mine sinkers	No. 22 Gainsborough (Feb 1918)
Trench Warfare Filling Factories (TWFF)	
Filling 2-inch Trench Mortar bombs Filling 3-inch Stokes Mortar bombs	Erith (Oct 1915) Watford no. 1 (Oct 1915) Denaby (Jan 1916)
Filling Heavy Trench Mortar and aerial bombs	Watford No. 2 (May 1916)
Filling Ball grenades, 3-inch Stokes bombs	Fulham (Aug 1915)
National Factories for Filling and Assembling Chemical shell	
Filling lachrymatory grenades and shells	Walthamstow (Aug 1915)
Filling lethal chemical shells	Greenford (Feb 1917)
Filling HS (mustard gas) shells	Chittening (Jun 1918)

Table 4.4 Types of work undertaken by National Filling Factories.

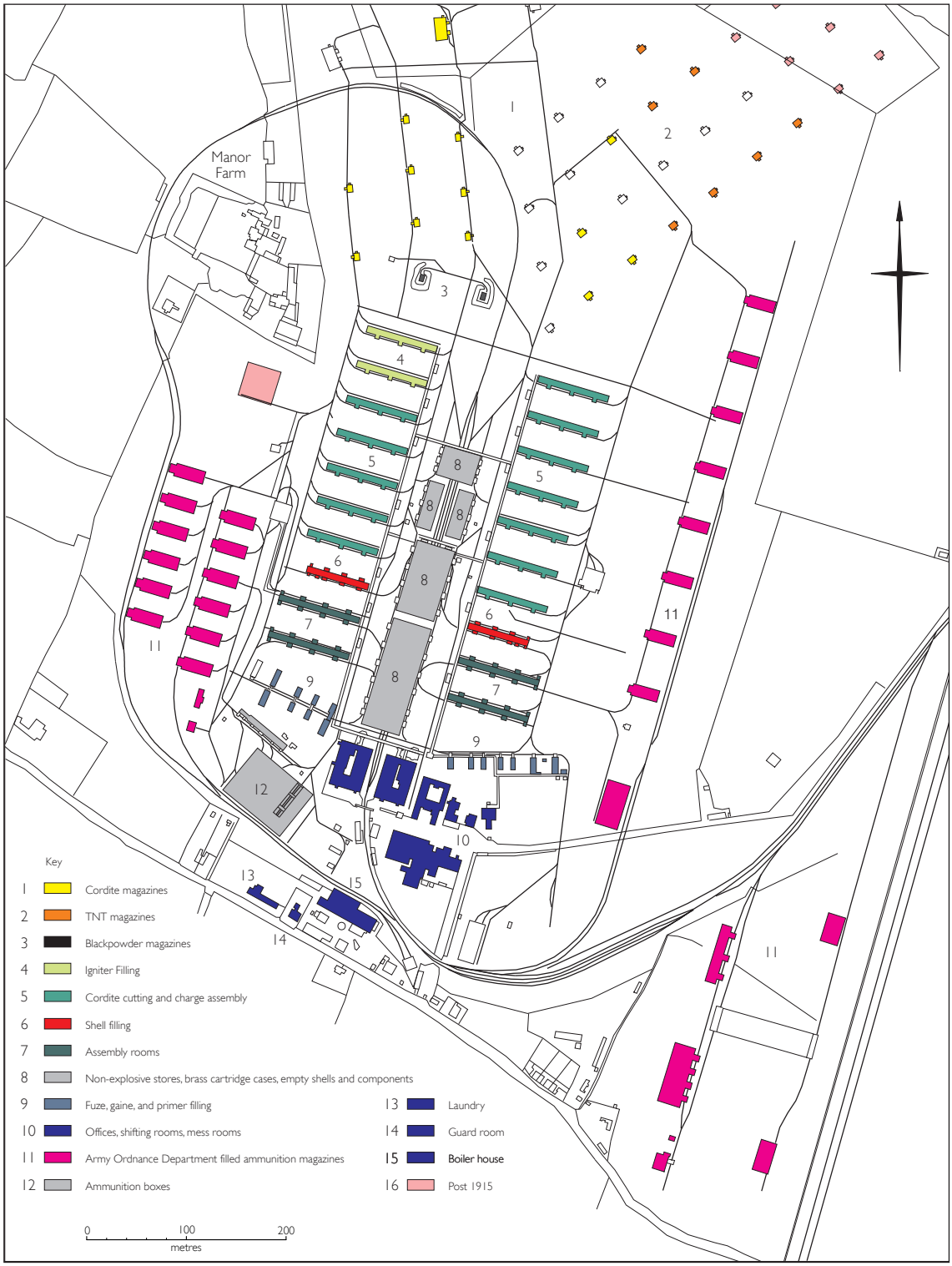


Fig. 4.19. NFF No. 5 Quedgely, plan (redrawn from OS map of 1923, © Historic England).

Factory Characteristics

'Quick Firing' and 'Breech-Loading' Assembly

The first group of filling factories were those concerned with the assembly of QF ('Quick Firing') ammunition for field artillery. These factories needed to assemble a wide range of different components into a finished round, including a brass cartridge case with igniter filled with cordite, to which was attached a shrapnel or HE (high explosive) shell, which in turn contained a bursting charge, gaine and finally a fuse. The relatively small amounts of explosive needed in these shells could be filled using pre-formed blocks, so no melting or heating was required.

Similarly 'Breech-Loading' or BL ammunition was used by guns of 60pdr and larger calibres. In these cases rather than having a brass cartridge the cordite propellant charge was cut to length and sewn into a tight-fitting cloth bag. Cartridges for these weapons were assembled in a similar way to QF rounds, but were not 'fixed', i.e. attached to the shell directly, rather they were loaded into the gun separately.

NFF No. 5 at Quedgely in Gloucester was one such factory, constructed during the winter of 1915, which started producing shells by March 1916. The factory was designed to operate with a production flow outwards from the centre (see Fig. 4.19). Non-explosive raw materials were delivered to a series of large stores on the central north-south axis of the factory. Supplies of cordite propellant and other explosives were delivered to a range of magazines dispersed in the area to the north. Materials were then moved by trolleys and raised 'clean-ways' to assembling huts where the various components were brought together. QF ammunition was assembled in the

Fig. 4.20. NFF No. 5 Quedgeley under construction, 1915. View looking north along the central axis of the site with component stores to the left and assembly huts on the right (TNA MUN5/157).

huts to the west of the central axis, and BL cartridges to the east. Finished product was then delivered to Army Ordnance Depot stores at the western and eastern limits of the site respectively, where they could be reloaded onto trains for delivery.[123]

As the history of the site records '...practically the whole factory was built of ¾ inch weather boarding lined with ½ inch match board'. [124] With the exception of the boiler house and certain magazines the whole site consisted of single-storey wooden huts (Fig 4.20). This was partly a consequence of the need for speedy construction of the factory, but also it would have meant that any explosions would have resulted in relatively little debris. Apart from that, there seems to have been relatively little protection from accidents. Few of the buildings on the site appear to have been protected by earth bunds, the buildings containing significant quantities of explosives simply being dispersed over a large area of the site. This was possibly because smaller calibre shells, and shrapnel shells in particular would have contained relatively small amounts of explosive, and this material was not required to be heated or poured as it was in other factories. Thus any individual process building was unlikely to hold a large quantity of explosives at any one time.

The early factories at both NFF No. 1 Leeds (Barnbow) (Fig 4.21) and No. 2 Liverpool (Aintree) followed a similar pattern to Gloucester. In each case materials were delivered via a central axial railway siding, with component stores either side, and dispersed magazines at the far end. Production then flowed outwards to filled shell stores at the edges of the sites. Construction was also very similar with the extensive use of single-storey huts and little earth bunding or blast protection.[125]

Fig. 4.21. NFF No. 1 Leeds (Barnbow). Interior view showing 18pdr assembly (undated). Note the single-storey wooden hut, Belfast Truss roof, and lack of blast protection (TNA MUN5/157).

Lyddite

At the same time as the QF factories were established in 1915, factories were also set up to fill larger calibre shells (typically 4.7-inch and above). At the outset of the war the typical filling for these was picric acid or lyddite. NFF No. 9 Banbury was established to carry on this work (Fig 4.22). The factory at Banbury was constructed in the spring of 1916, and its layout was based on the pre-war factory run by Armstrong Whitworth and Co. at Lemington Point.

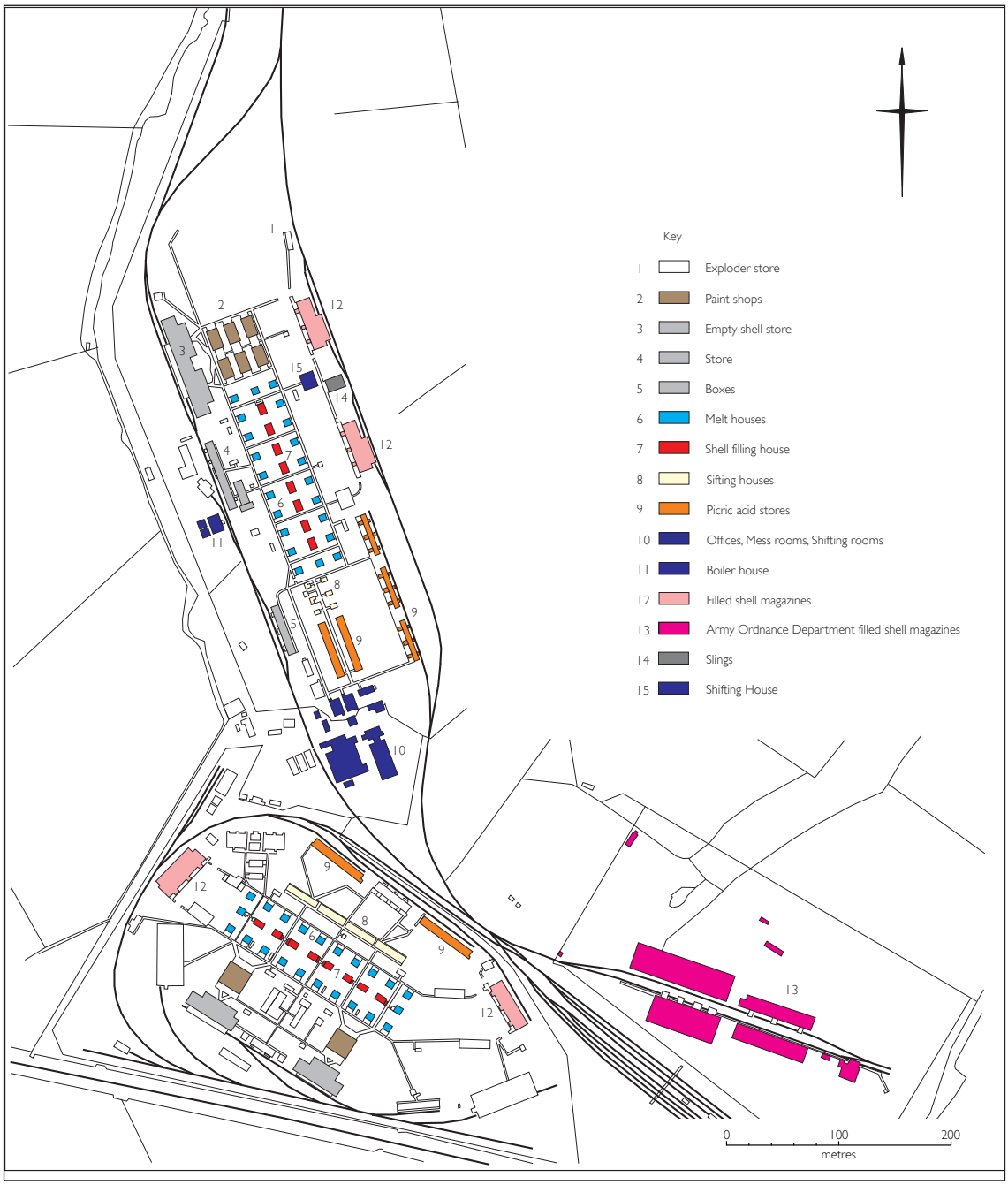


Fig. 4.22. Plan of NFF No. 9 Banbury (Redrawn from OS map of 1922, © Historic England).

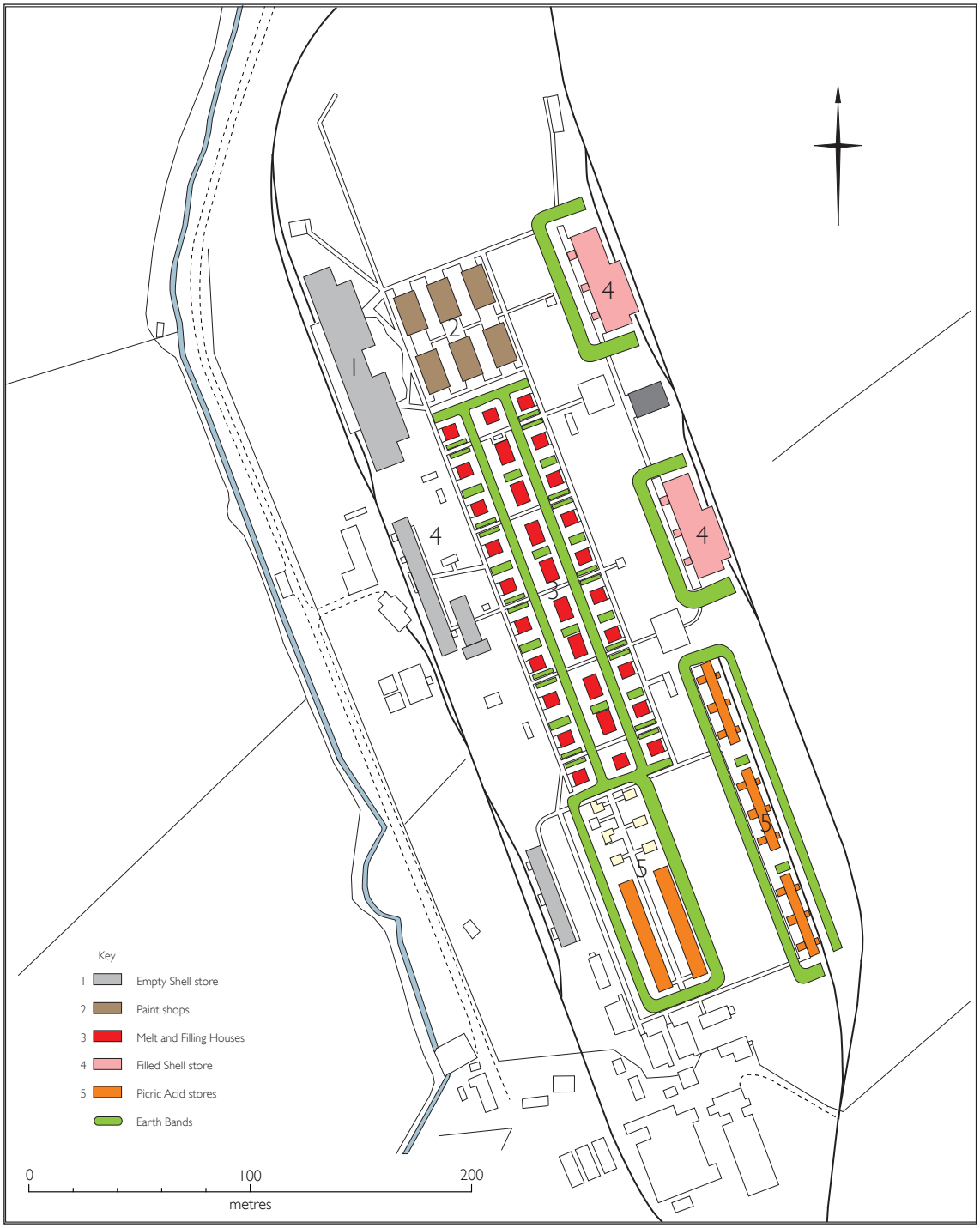


Fig. 4.23. NFF No 9 Banbury, plan showing un-bunded empty-shell stores (left) and paint shops (top), bunded melt and filling houses (centre), and filled-shell stores (right) bunded on three sides (redrawn from O.S. 1:2,500 map Northamptonshire 1922).

Two separate filling plants were ultimately built at Banbury; No. 1 to the north and No. 2 to the south. Each was slightly differently laid out but the principles were similar. In the case of No. 1 Factory empty shells and components were delivered by rail to stores on the western side of the site (Fig 4.23). A fixed level was established equivalent to the height of the floor of the railway wagons. All work benches and the bronze-wheeled, clean-way trolleys used to move the shells around were designed

to be at this exact height, so shells did not have to be lifted at any point while being processed but could be rolled from job to job (see earlier Fig. 3.10). On arrival the shells were first cleaned and lacquered in a paint shop to protect the steel from the acid effect of the lyddite. Explosive was brought from stores on the east side of the site and sifted before being melted. This was done in individual containers placed in an oil bath over a gas flame. These containers were then taken on to the filling-houses and the explosive poured into the shells.[126] Both the melting and filling was carried out in a series of small wooden huts. As significant quantities of explosive were being handled in each hut, and heated, each was surrounded with its own earth-bund blast protection. Gaps only wide enough to admit the trolleys of shells were made in the bunds. Finally the shells were delivered to filled-shell stores on the east side of the site. These stores were bunded, but only on three sides, the external face being open to allow the force of an explosion to dissipate outwards across the adjoining fields. The components of this factory, including the huts, were sold off after the war, but the earthwork bunds remained in situ and these survive on the site allowing a substantial picture of the layout of the factory to be seen.

A similar lyddite filling factory was constructed at NFF No. 14 Hereford in July 1916. The site was initially intended to provide reserve capacity in case of accident at one of the large amatol filling factories at Morecambe or Chilwell, but increased national supplies of lyddite provided the opportunity for the construction of additional filling capacity for this explosive as well. The lyddite plant at Hereford was similar to that at Banbury, with several large empty shell stores feeding a series of small melting and filling houses, connected by raised clean-ways, however photographs of the site suggest that only the explosives magazines were shielded by earth bunds.[127] Very little of the lyddite factory at Hereford survives as the site was reconfigured for munitions manufacture in the Second World War and much of the 1916 infrastructure was demolished. Nonetheless one empty-shell store and several explosives stores survive, and one of these is designated as a Grade II listed building (Fig 4.24).

Fig 4.24. NFF No. 14 Hereford, surviving picric acid expense store (W Cocroft).

Amatol

Experiments in the Research Department at Woolwich in April 1915 showed the viability of amatol as a shell filling. However, as already described, filling with this explosive was problematic as the preferred type, 20% TNT and 80% ammonium nitrate (known as 80/20 amatol), did not melt satisfactorily and could not be poured. Initially private contractors were used to provide pre-formed blocks of finished explosive which were sent to the QF filling factories, however a method for filling larger calibres was required.[128] One solution to this was to create a powder mix by milling the two ingredients in a similar fashion to the manufacture of gunpowder. This powder would then be 'stemmed' (poured) into shell casings. Initially this was then compacted by hand using a mallet and a wooden drift, but later mechanical presses were introduced. A void was also pressed into the top of the mix which was then filled with pure melted TNT to improve the reliability of detonation.[129] Plants carrying out this type of filling were established alongside the existing factories at NFF No.1 Leeds, No.2 Liverpool, (and No.4 Georgetown in Scotland). Only Gloucester among the early QF factories was not so equipped. The layouts of the amatol sites at Leeds and Liverpool were similar, with a rectangular loop of rail lines enclosing empty and filled shell stores, 'incorporating houses' where the mixtures were prepared, and press houses where the shells were filled.

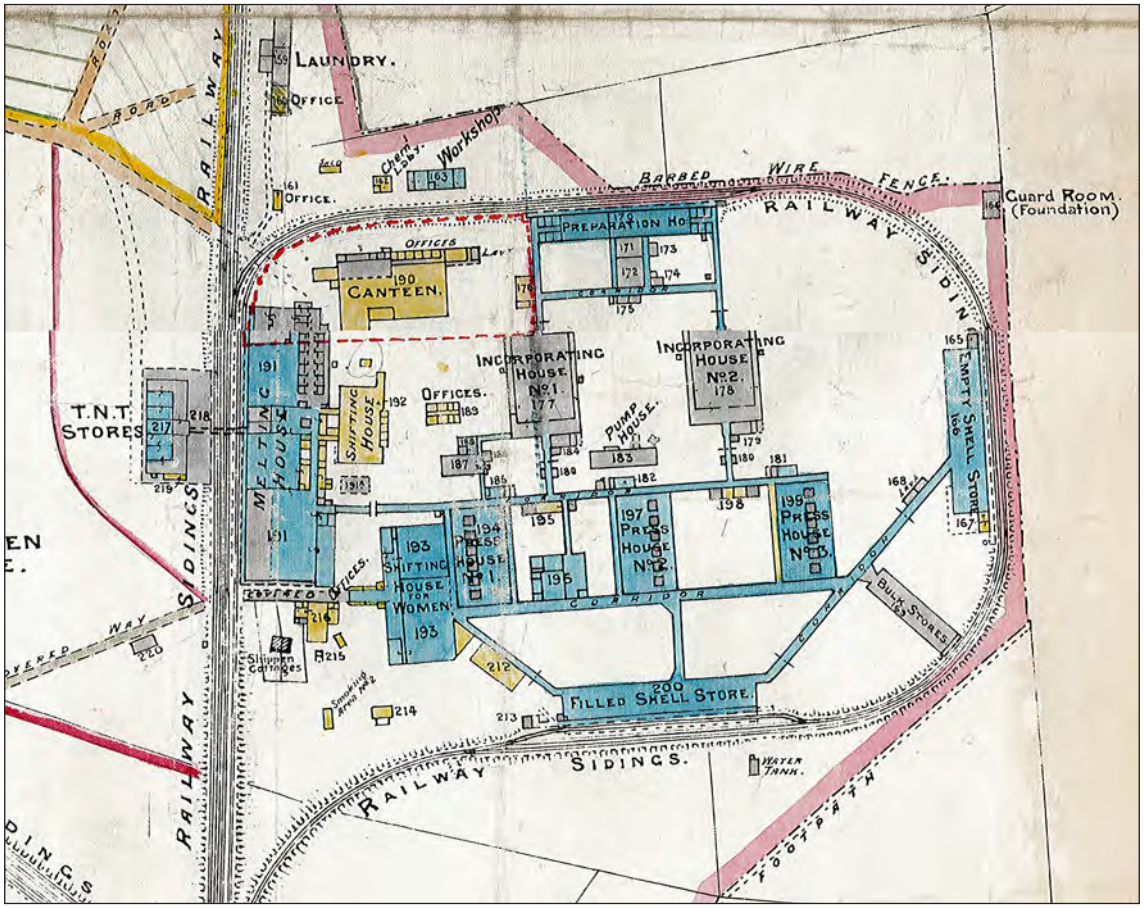


Fig. 4.25. NFF No. 1 Leeds (Barnbow), Amatol Section showing the melting, incorporating and pressing houses for this explosive, 1924 (West Yorkshire Archive Service, Leeds: WYL115/MA/6).

Amatol filling factories based on this process of batch-mixing ingredients using edge-runner mills were also established at NFF No.13 Morecambe, and NFF No. 14 Hereford. The plant at Hereford in particular was established as a back-up in case of accident at the Chilwell factory (discussed below). At Hereford six production lines were established in parallel, each having its own bunded TNT magazine, a large empty-shell store, and mixing and press houses. Each unit was designed to process 100 tons of explosive per week. Although the mixing and pressing buildings have been demolished, five out of six of the empty-shell stores as well as finished-shell stores and TNT magazines survive on the Hereford amatol site, as well as the factory offices (see Appendix B).

By 1918 a different filling process was also developed at Hereford whereby the mixture was heated to make a malleable paste which was then filled using a screw mechanism. 'Melt houses' (which were already a feature of these factories for melting pure TNT) were adapted for this process (Fig 4.25).[130]

One of the most significant amatol processing and filling factories was that built as NFF No. 6 at Chilwell, near Nottingham (Fig 4.26). This factory was designed and

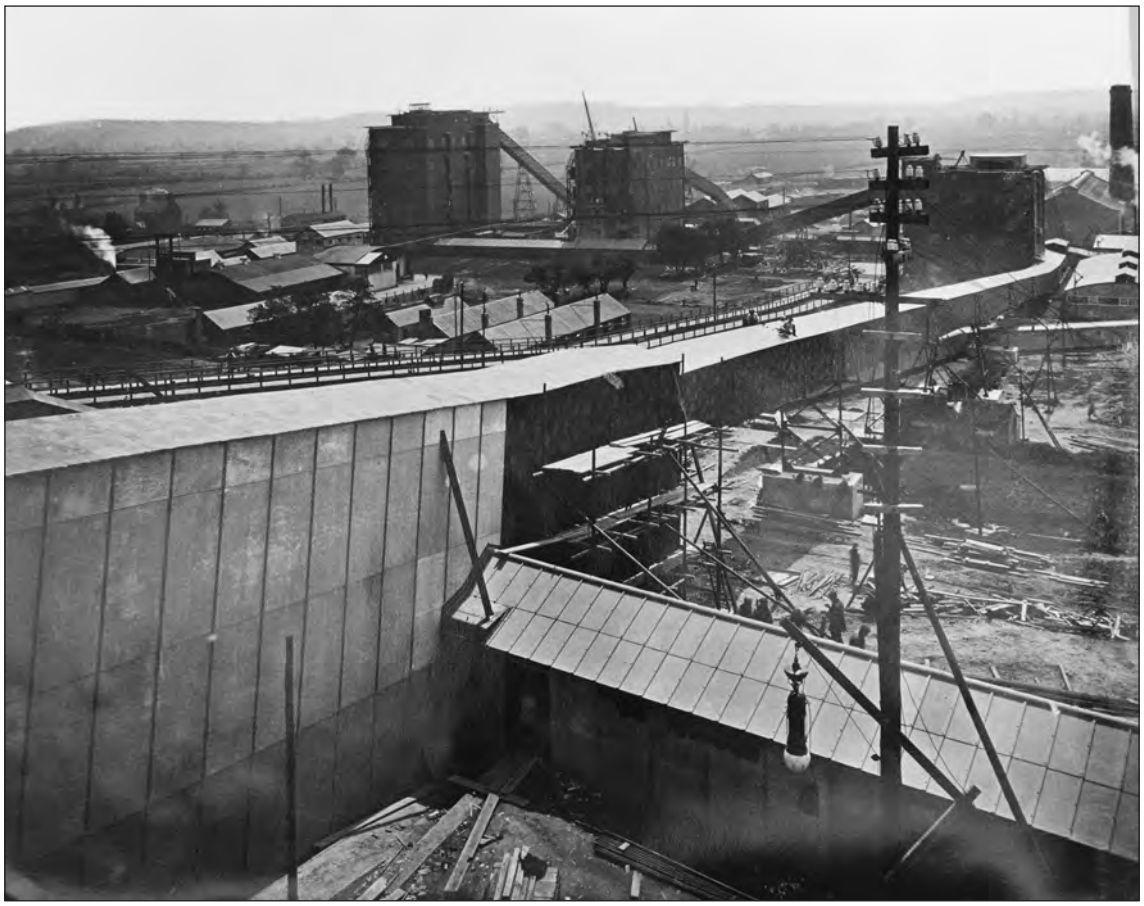


Fig. 4.26. NFF No. 6 Chilwell. View taken on 17 May 1916, looking south. The ammonium nitrate mill is on the centre left, with the TNT mill next right, then the mixing house. Covered conveyor belts carry the mixed amatol to the press houses located behind the camera position (© Historic England AA96/03602).

built in September 1915 under the auspices of Lord Chetwynd. This plant used an innovative series of processing machines, copied from a range of other industries, to mix 80/20 amatol. Multi-storey structures were built to dry and crush TNT and ammonium nitrate using machines originally used in quarrying and sugar-making, to produce a very fine flour-like powder which was then mixed and carried, while still warm from milling, by conveyor belts to pressing houses. This continuous process was more efficient that earlier milling arrangements which could only manage small batches of material at a time. Great trouble was also taken to remove moisture from the finished explosive, and to avoid any shaking which might separate the two mixed constituents.[131]

After filling the shells were moved to a very large filled-shell store building. This building was the subject of many often-reproduced photographs, and is still present on the site, in use as an army stores depot (Fig 4.27). The milling and mixing buildings as well as the press houses have all been demolished, although various other smaller structures also survive.

Fig. 4.27. NFF No. 6 Chilwell, the interior of the shell store. (© Historic England AA96-03350).

Fuse Filling

Filling of fuses, gaines, detonators and other small components was undertaken at a number of factories. Some of these also carried out larger filling tasks. NFF No. 7 Hayes produced large numbers of fuses but also carried out filling and assembling of QF ammunition, as well as some filling of larger (4.7-inch and 6-inch) shells with melted amatol (presumably 60/40). Although larger specialist buildings were required for the amatol work, the remainder of the factory was housed in large numbers of simple timber-framed huts (Fig 4.28).

Fig. 4.28. NFF No. 7 Hayes, January 1916, showing layout of huts and clean-ways (TNA MUN5/154).

The huts were typically 15ft by 40ft, which was quite large enough to accommodate work on small components, and filling with commensurately small amounts of explosive. Also the standardisation allowed versatility in the uses to which buildings were put, as production methods and priorities changed. A published history of the site records:

> Over 200 of the shops were of the same size 40 feet by 15 feet. This standardisation permitted them to be speedily re-arranged for work in the frequently changing allocations. For example one particular shop has been used in turn for filling primers, cutting cordite, assembling cartridges, and assembling 18pdr ammunition.[132]

These huts were connected by raised clean-ways, and access to the whole system was controlled through shifting houses where staff changed clothing and footwear.

NFF No.10 Coventry exhibited a similar layout. In 1915 the factory consisted almost entirely of single-span timber huts. However a plan of the site from late 1916 suggests that an area of more substantial brick-built workshops was constructed. These had saw-tooth north-light roofs. Photographs also survive of women working on fuses in workshops with steel-framed roofs consistent with these buildings. However it is not clear if these pictures were taken at NFF No.10 or at another Coventry factory.[133] Parts of these buildings survive on the site (see Appendix B).

Trench Warfare Filling Factories (TWFF)

Unlike larger ordnance, most mortar rounds were initially filled with ammonal; a mix of TNT, ammonium nitrate, and the added ingredient aluminium powder. Thus in 1915 a number of factories were established to fill these rounds. At that time ammonal was only produced by commercial factories, and the first filling factories were positioned to take advantage of this supply of explosives. TWFF Erith was built near to Thames Ammunition Works, and TWFF Denaby, near Rotherham was built near to the British Westfalite Company. In addition the Ministry set about creating its own ammonal production facility and an filling factory in Watford. HMEF Watford (on Balmoral Road) was built to supply the explosive, and two trench mortar filling factories were constructed, TWFF Watford No.1, located next to the explosives works, which filled 2-inch and 3-inch mortar rounds, and TWFF Watford No.2, which filled larger mortar rounds as well as aerial bombs. In 1917 ammonal was replaced as a bomb filling with 80/20 amatol, but filling continued by hand with explosive supplied ready-mixed. A further factory engaged in hand-grenade filling was also nationalised in 1916 to become TWFF Fulham.[134]

Surviving photographs of the two Watford factories show assembly of both 4-inch Stokes bombs and rifle grenades in typical timber huts with wooden trussed roofs. Post-war Ordnance Survey mapping, however, suggests that larger structures were also present, and one photograph survives depicting the workforce of TWFF Watford No.1 in front of a substantial three-story brick factory. No further information concerning the character of these sites has been identified.

Chemical Shell Filling

The filling of chemical shells fell into two categories. First there was the filling of chemical munitions such as incendiary and smoke shells (for example filling Stokes mortar rounds with phosphorus), then there was the filling of shells with chemical warfare agents including HS (mustard gas). The former kind of work did not require the elaborate precautions and safety measures necessary for the latter. Smoke and incendiary rounds were in particular demand for use in mortars and therefore much of this work was carried on at Trench Warfare Factories. Both TWFF Watford No.1 and No.2 carried on this work from the middle of 1916 onwards.[135]

Filling of shells and grenades with chemical agent was initially carried out at TWFF Walthamstow (Fig 4.29). This factory began as a commercial concern run by Baird and Tatlock, specialist glass manufacturers who were capable of producing the internal glass vessels which contained the chemical agents in the grenades. This

factory was nationalised in June 1916. Initially, this plant was principally concerned with the manufacture of lachrymatory (tear gas) grenades, but later went on to fill larger shells up to 6-inch with these same agents. Some work was also done filling Livens projector drums. Filling with lethal agents was also carried out.[136]

Fig. 4.29. TWFF Walthamstow. Lachrymatory grenade filling (undated). Note the youth of several of the employees (TNA MUN5/368).

In the spring of 1916 the use of lethal agents in artillery shells was approved. Agents such as phosgene or chloropicrin were used to fill shells. The filling of the shell with agent, or 'charging' was carried out by the commercial manufacturers, but the final stage of incorporating a fuse and a bursting charge, known as 'assembling' was carried out at National Factories, including Woolwich. The problem of handling potentially leaking gas shells in these factories led to the establishment of a specialist 'Chemical Shell Assembling Station' at Greenford in Middlesex (Fig 4.30). Construction began in August 1916.[137] Surviving plans of this site show it to have been a relatively simple rectilinear layout of timber huts, connected by clean-ways, with three earth-bunded magazines for storage of the 'Fumyl' explosive used for these shells (a mix of TNT, ammonium nitrate and ammonium chloride). Large empty- and filled-shell stores were also provided.[138]

The development of mustard gas, known by the British abbreviation 'HS' led to an expansion of gas charging and assembling in 1918. A purpose-built factory was created at NFF Chittening near Bristol with the aim of both manufacturing and filling shells with HS. Work commenced on the site in January 1918. It was

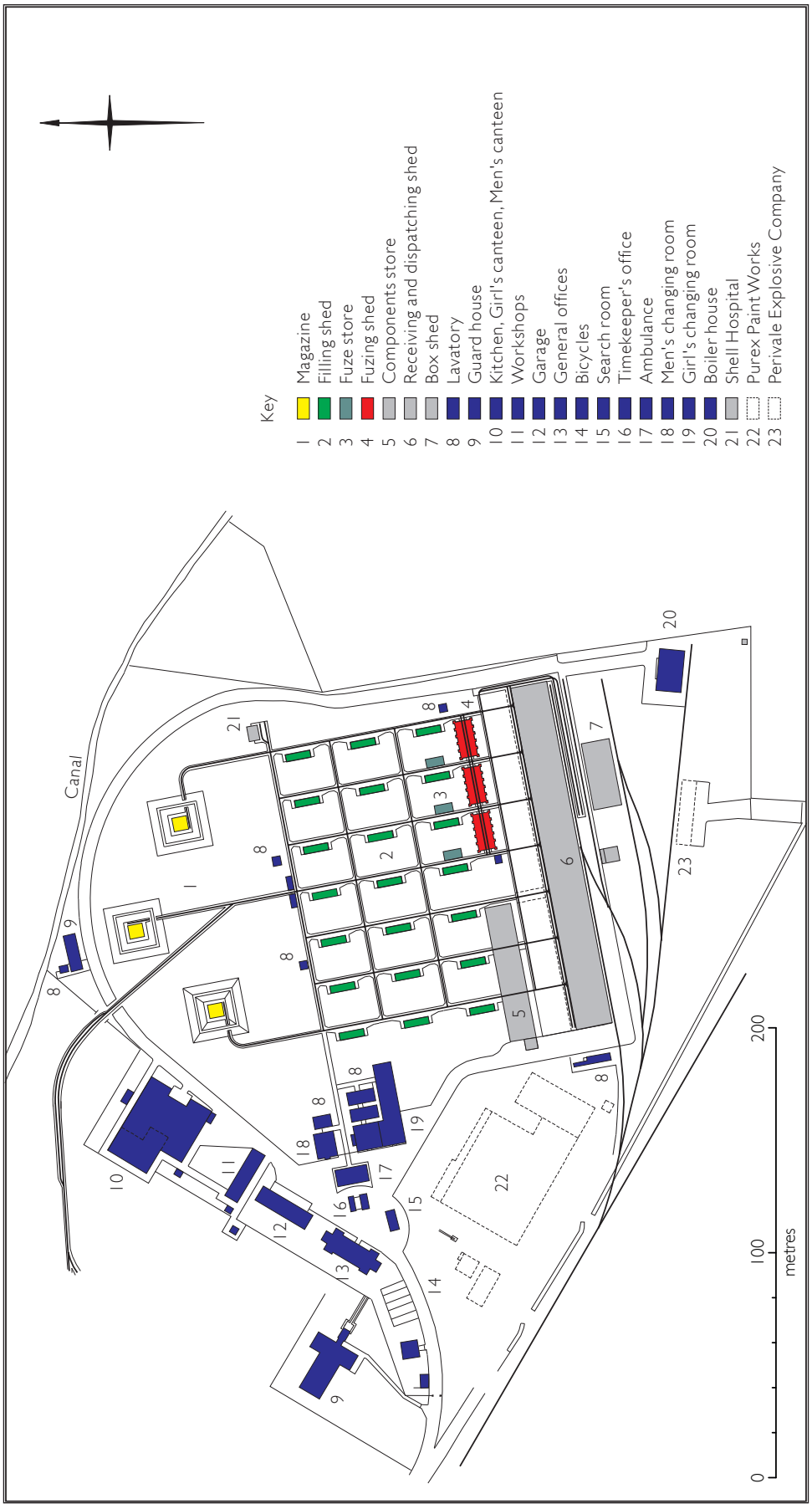


Fig. 4.30. Chemical Shell Assembling Station Greenford, plan (redrawn from Wootton and Lowry 1919).

decided, however, that the production of the agent should be separated from the filling process, and HS manufacturing was transferred to the nearby HMEF Avonmouth, a site which had been constructed to produce picric acid but had yet to go into production. HS was also produced commercially by Messrs Levinstein in Manchester. Output of both production sources was delivered to filling sites by rail in tankers.

Work at Chittening was initially very hazardous (Fig 4.31). The gravity-fed shell-filling mechanism was extremely leaky and it was almost impossible to prevent staff coming into contact with both liquid agent and vapour. Nor were suitable ventilation systems installed for the huts where the filling was carried out. Casualty rates among employees initially ran at 100%, everyone became sick and whole shifts had to be replaced. Later, the filling system was altered to one with the flow of agent controlled by a more reliable vacuum system, and proper ventilation was installed. Nonetheless, gas casualties among the workforce remained high throughout.[139]

Fig. 4.31. NFF (Chemical) Chittening, air photograph, 1927 (© Historic England EPW019258).

From the summer of 1918 the increase in demand for HS shells, combined with a plentiful supply of agent, led to additional filling capacity being required. As Lyddite filling had declined at both NFF No.9 Banbury and No.14 Hereford, these two sites converted some of their production to both HS charging (filling) and assembly. Some filling was also carried out at NFF No.13 Morecambe. Improved methods of both filling and ventilation had been introduced, but gas casualties remained high. Normal explosive shell filling was typically carried out via the opening at the tip of the shell, which would subsequently hold the fuse. For gas shells, however, this opening was blocked by a gas-tight fitting which held the bursting charge and fuse.

The HS (actually a liquid, but one which readily evaporated into fumes at room temperature) was inserted via a hole drilled in the side of the shell casing which was then blocked by hammering in an iron plug. This process had great potential for spillages and for fume inhalation. The official report on HS filling at Banbury gives an account of the effects, but offers little sympathy for the victims:

> The greatest trouble experienced was undoubtedly the difficulty of keeping staff on H.S. charging due to the large number of casualties. [...] The burns that were reported from Charging Machine Operators, were mostly due to carelessness. The fact that we have Operators who have worked machines all the while without being burnt - proves this is so.[140]

Exposure of equipment to fumes could also result in the absorption of gas. Wooden work-benches, linoleum floors, and shoes and clothing could absorb harmful levels of agent and cause blistering as a result. The signing of the Armistice led to an end to production before these problems were satisfactorily solved.

4.5 GOVERNMENT FACTORIES FOR CARTRIDGES AND SMALL ARMS AMMUNITION

Purpose

In the spring of 1916 demand for small arms ammunition reached new heights. Ammunition was manufactured at Woolwich but the remainder of production was in the hands of private firms (Fig 4.32). It was estimated that 150 million rounds per week were required, and plans were drawn up for National Factories to supply up to 30 million.

Fig. 4.32. Royal Arsenal, Woolwich, Small Arms Factory 3, women workers finishing small arms ammunition, May 1918 (© IWM Q 27880).

Using a similar method to that used for establishing the National Projectile Factories, existing manufacturers were funded to create additional factories near their existing production facilities, which they would then run as agents for the Ministry of Munitions. Four factories were established:

- GCF No.1 Blackheath, Staffordshire, managed by the Birmingham Metal and Munitions Company (12,000,000 rounds per week)

- GCF No.2 Woolwich, managed under the auspices of the Royal Arsenal,

Woolwich (6,000,000 rounds per week)

- GCF No.3 Blackpole, Worcestershire, managed by the King's Norton Metal Company (6,000,000 rounds per week)

- GCF No.4 Edmonton, London, managed by the Eley Brothers (6,000,000 rounds per week).

Construction of the factories began in the summer of 1916, and all but the Edmonton site started to produce .303-inch rounds. However in July 1916 it was decided that the output of these factories should be used to support the ailing Russian army on the Eastern Front. Production demand was halved to 15 million rounds per week and the plants were retooled to produce Russian-pattern 7.62mm ammunition. After the collapse of Russia in the winter of 1917 production was switched back to .303-inch work, and the factories at Blackheath and Blackpole continued to produce these rounds until the Armistice. In 1918 the Edmonton site was switched to aero-engine repair work. In 1918 the factories still engaged in ammunition production employed around 3,500 people each, although the workforce at Edmonton had halved to about 1,500. Of these around 80% were women.[141]

Four other sites were also controlled by the Ministry in connection with the supply of small arms ammunition. These were the specialist incendiary ammunition factory established at Coundon near Coventry, the brass rolling mills in Southampton, and two small workshops in Sheffield concerned with bullet manufacture. These are also described in the relevant sections below.

Factory Characteristics

Government Cartridge Factories

The four Government Cartridge Factories were built on broadly similar lines. Each took the form of a large rectangular brick-built factory with saw-toothed north-light roofing. Much of the floor area was occupied by a single large machine shop, but offices and other specialist spaces were attached. Separate earth-bunded magazines for cordite storage were provided, and these were connected to the main factory by trolley lines. The post-war sale particulars for the Edmonton factory survive in The National Archives and include a plan of the site.[142] This shows a broadly square 'Main Factory' with offices along one frontage (Fig 4.33). Adjacent are the cordite magazines, and a long, 'L'-shaped multi-bay structure marked as the 'Filling Building', presumably built with explosive safety considerations in mind. The main factory was described thus:

> The Buildings have all been erected by the Ministry since 1915, they are well and substantially built of brickwork and steel stanchions, with concrete floors, slated and glazed roofs on the saw tooth pattern with north lights, and the slated portion is timbered on the inner side of the rafters.[143]

The report goes on to describe arrangements of heating, light, water and electricity

supply. The main shop is given as 16,800 square yards in area, with a clear height to the roof trusses of 14ft 6in. After the war the buildings were sold to the Rego Tailoring Company, (Fig. 4.33), and the test-ranges and magazines were removed but the main workshop was retained as a warehouse. This has now been demolished.

Fig. 4.33. GCF No.4 Edmonton, air photograph, 1933 (© Historic England EPW042088).

A similar layout was used for GCF No.1 at Blackheath in Birmingham, and although the main factory was also demolished in the 1990s, its form can be seen in earlier aerial photography (Fig. 4.34). A large rectangular assembly shop was surrounded by ancillary buildings, with magazines at some distance away to the east.

The only one of these factories to survive, that at GCF No.3 Blackpole, Worcestershire, is arranged and constructed on the same pattern (see Appendix B). This building is also a large square brick structure with north-light roofing and with a series of offices along its front elevation. Some ancillary parts of the site such as the cordite magazines have disappeared but the main factory itself survives more or less complete.

National Small Arms Ammunition Factory

In 1917 an urgent requirement developed in the Royal Flying Corps for incendiary ammunition for use against Zeppelin airships. These craft were carrying out bombing raids on London and elsewhere, and a round was needed which would ignite the flammable gas in the airships. The round was developed, based on a design manufactured initially by Richard Threlfall & Sons, and was as a result

Fig. 4.34. GCF No.1 Blackheath (Birmingham) air photograph, 1924 (© Historic England EPW010510).

known as 'RTS' ammunition. This contained a small charge of nitro-glycerine and phosphorus.[144] In some haste, and in great secrecy, the National Small Arms Ammunition Factory Coundon was built near Coventry to produce these rounds. The factory was very small, employing fewer than 100 people, and was accommodated in temporary wooden huts.[145] Neither the exact location, nor the layout, of this factory has been identified in the course of this project.

Government Rolling Mills

By the summer of 1916 demand for small arms ammunition reached 550 million rounds per month. To meet this, substantial quantities of brass and cupro-nickel were required for cartridge cases and bullet jackets. The Government Rolling Mills, Southampton, were established to supply this material, in the form of brass cups, which could be pulled into finished cartridges, and cupro-nickel strip (Fig 4.35).

From the outset the factory was designed on a very large scale and up to 950 tons of metal could be cast in any one week. The site was scientifically laid out, with a linear production flow from west to east along a series of buildings half a mile long, starting with the power house and gas works at the west end, followed by the foundry, rolling mills, and finally finishing and storage areas. Raw materials, and coal for the furnaces were imported by ship to a jetty at the western end. This was raised on a concrete runway which both allowed for the contingency that the railway might need to be connected to the nearby main line, and also allowed for materials to be dumped directly into hoppers by bottom-opening wagons.[146] The cup stamping process left a large amount of scrap brass, but this was simply re-melted and used over again. The finished cups were then dispatched in sacks to cartridge factories where the pulling and finishing would be carried out. The factory operated briefly after the war casting

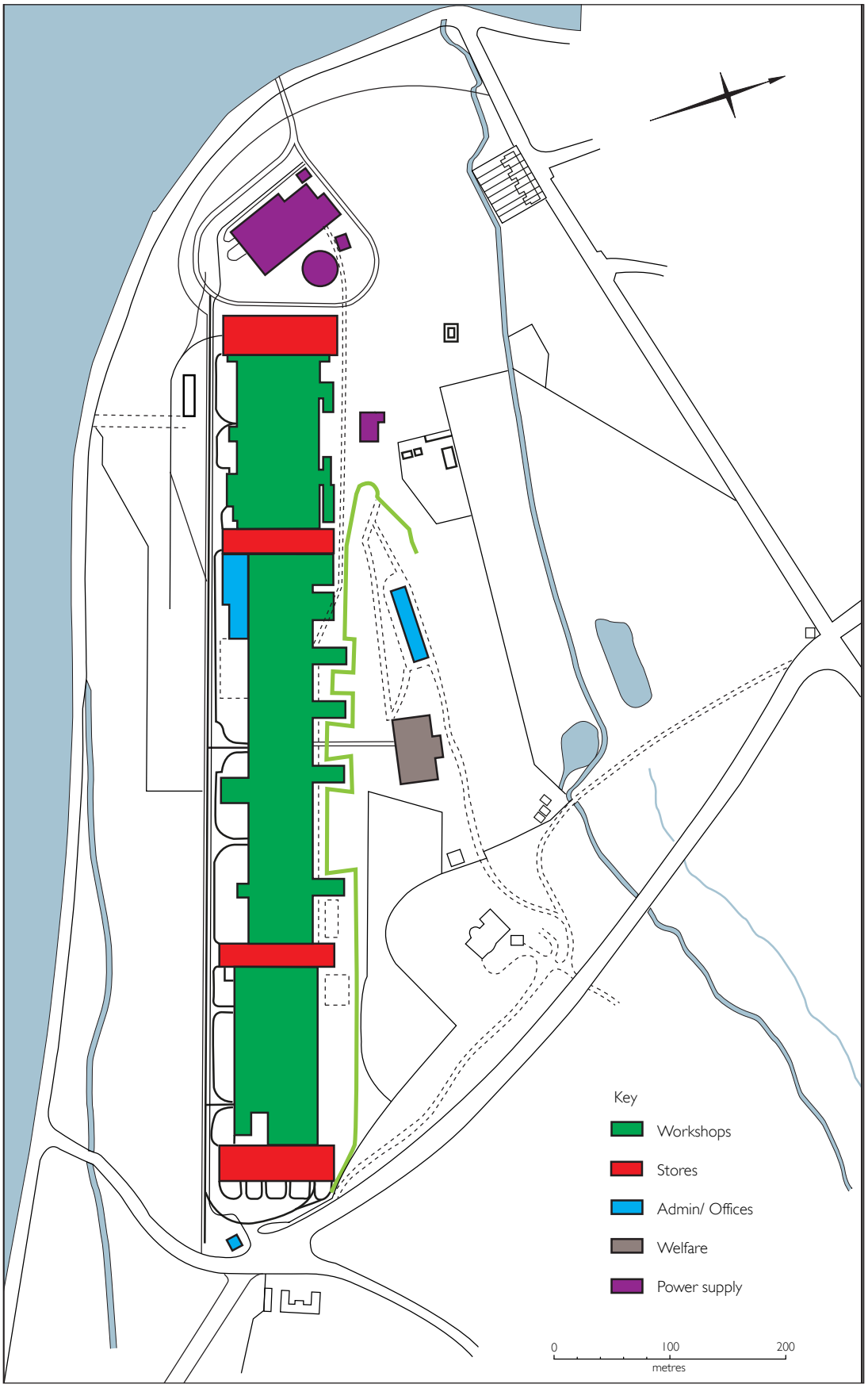


Fig. 4.35. Government Rolling Mills, Southampton. Plan (redrawn from The Engineer *1919).*

ingots from scrap before being taken over as an electrical gear factory. The site is now occupied by housing.

Manufacturing Warehouse and Casting Shop

In 1918 two additional small works were set up under Ministry control in Sheffield. The first of these was at No.50 Porter Street and was used for the production of cupro-nickel ingots for small arms ammunition. This work was halted later in the year but the building was retained, first as a store and later as an inspection shop for nickel ingots. Porter Street no longer exists as the whole area has been redeveloped. The second factory was at Bacon Lane, formerly owned by Messrs Kent Smith Ltd. Here bullets were manufactured from cupro-nickel strip by a special electrical process. This site was closed in 1919.[147]

4.6 NATIONAL FACTORIES FOR AIRCRAFT PRODUCTION

Purpose

Prior to the war the only government facility for aircraft manufacture was the Royal Aircraft Factory (later Royal Aircraft Establishment) at Farnborough (Fig 4.36). This site had been established as a balloon factory in 1905, but after 1913 concentrated on heavier-than-air craft as all work on airships passed to the Navy. However the output of aircraft from Farnborough was small. Most machines were built by contractors, and the Royal Factory concentrated on research and development work. All aircraft built by outside contractors were also initially delivered to Farnborough for final inspection and flight testing before onward delivery to the RFC. This latter practice had to be altered after 1915, as the backlog of aircraft awaiting testing grew too large, and inspection was delegated to other regional aerodromes. Farnborough also carried out engine research, and in conjunction with this took in significant numbers of engines for repair, a function it continued to exercise throughout the war.[148]

Fig. 4.36. RAE Farnborough, the original post-1905 balloon factory, (now demolished) 1998 (© Historic England BB98/26770).

By 1917 it became apparent that extra capacity was needed in addition to the factories already in production under private contractors. As with other factory types it was realised that the issuing of further contracts to small firms would be inefficient and what was needed were a few large factories. Following the model of the National Projectile Factories previously established (discussed in section 4.3), approaches were made to existing manufacturers to create large new plants.

Three factories were built:

- NAF Croydon (No.1), managed by Holland Hannen & Cubitt,
- NAF Heaton Chapel (No.2), (Manchester) managed by Crossley Motors,
- NAF Aintree (No.3) (Liverpool), managed by Cunard.

Initially it was intended that the third factory should be at Richmond, managed by Sopwith, but in the end this site was simply rented outright to Sopwith and never became a National Factory, the agreement with Crossley being taken up in its place. Supplies of engines and radiators were sourced from a number of private contractors, and as demand increased in 1918 several of these were nationalised, as output was considered to be inadequate and management inefficient. Engine plants at Ladbrooke Grove and Hayes were taken over along with radiator factories at Greet and Sudbury. Rapid increase in the demand for balloons also led to the take-over of a cinema in Finchley as a balloon factory.[149]

For aircraft production large quantities of seasoned ash wood were required. Contracts were placed with timber-drying companies, but two national drying kilns were also established. These took advantage of existing facilities within the railway carriage industry, and new kilns were constructed as part of the carriage works operated by the Great Western Railway at Swindon, and the London, Brighton & South Coast Railway at Lancing in Sussex.[150]

Factory Characteristics

National Aircraft Factories

At Farnborough manufacturing took place in a variety of hangars and other buildings which had been built *ad hoc* over the period since the site had opened for balloon work in 1905. As a result there was little scientific factory design apparent on the site. The new National Factories, however, were built in a style common with many of the other new-build factory structures commissioned by the Ministry of Munitions. Essentially they consisted of large north-lit brick factory buildings, with large open interior spaces and steel truss roofs supported by steel columns. Each appears to have been constructed to a slightly different pattern according to the whims of the individual contractors, but all had a similar overall appearance. The now demolished factory at Aintree is depicted on post-1918 air-photography after it had been converted into an artificial silk factory (Fig 4.37).

The buildings at Waddon (Croydon) were similar in plan but little photographic evidence of their construction has been identified. Parts of NAF No.2 at Heaton Chapel survive on the site (see Appendix B). These continued in use as the Crossley Motors car factory post-war and a section of one assembly shop survives. This building is notable for the use of roof trusses connected between bays by external beams at ridge height, a feature of several other National Factory buildings elsewhere (Fig 4.38).

Fig. 4.37. NAF No.3 Aintree, air photograph, 1928 (© Historic England EPW020354).

Fig. 4.38. NAF No.2 Heaton Chapel interior in 1918, showing DH9 aircraft under assembly (http ://en.wikipedia.org/wiki/National_Aircraft _Factory_No._2 #mediaviewer/File:NAF_ No.2_1918.jpg, accessed 04/11/2014).

Internally the factories were divided between engineering shops filled with benches and machine tools for the construction of individual components, and large open-plan assembly shops where the aircraft themselves were put together. Each factory was also placed next to sufficient level open ground for flight operations to take place if required; the Croydon factory was adjacent to Waddon aerodrome for example, while at Aintree the factory was placed next to the racecourse.

National Aero-Engine Factories

By August 1917 the demand for aero-engines was increasing rapidly. This was addressed at first by issuing contracts to private firms but, as was the case in several shell factories, dissatisfaction with the management of these firms led to several plants being nationalised. As these factories were already existing works they do not demonstrate any particularly uniform character, but were rather the product of individual pre-war design by the companies concerned.

The Clement Talbot works at Ladbroke Grove was assigned work repairing Rolls Royce engines (Fig 4.39). Friction over repairing a rival firm's product led to the nationalisation of the plant in January 1918, after which repair of Rolls Royce aero-engines was carried out and spares for Talbot motor cars were produced.[151] The Talbot Factory on Barlby Road was constructed originally in 1903. The main workshop buildings on this site have been demolished but the administration building survives and is listed at Grade II (see Appendix B).

Fig. 4.39. National Aero-Engine Factory Ladbroke Grove (© Historic England DP 096484).

The second factory to be taken over by the Ministry was that of Messrs Mitchell, Shaw & Co. Ltd in Hayes, Middlesex. This factory was established in January 1917 in the former Goss printing works on Blyth Road for the supply of aero-engine

parts. The factory was initially administered by Mitchell, Shaw and Co. but was nationalised in October 1917 after output was found to be unsatisfactory. The factory became known for the quality of its output, partly as a result of the higher than average wages paid to staff. This factory is marked on the 1914 Ordnance Survey map and appears to be still extant (see Appendix B).

National Balloon Factory

At the end of 1917 it was decided to establish a new factory for the manufacture of static kite balloons. These were used by ships for anti-submarine spotting, and also as barrage balloons for civil air defence. A suitable location was chosen in the Bohemia Picture Palace, off Ballards Lane, Finchley, north London (Fig 4.40). Arrangements were made with several private companies to operate the factory but none proved satisfactory and the factory was eventually opened in April 1918 under direct control of the Ministry.[152]

Fig. 4.40. National Balloon Factory Finchley, the interior of the Bohemia Picture Palace in use for balloon manufacture, date unknown (Friern Barnet & District Local History Society).

The cinema consisted of a large hall approximately 95ft by 60ft, but also had an external courtyard garden area as well as a glazed loggia or 'Winter Garden' at the front, originally used for teas and dances. Access was via a pair of Moorish style arches and the interior was highly decorated with stucco and with a 'grand staircase'. After the war the factory was sold to the Kiwi boot polish company. The building remained standing until 1994, when sadly it was demolished, as it must have been one of the most lavishly decorated buildings to serve as a National Factory.[153]

National Radiator Factories

Prior to 1918 the manufacture of radiators had been entirely in private hands. It was a specialised business carried on mostly by small companies, with a highly skilled (and highly unionised) workforce. During 1917 the Royal Flying Corps started to develop a multi-engined heavy bomber force, and unlike the lighter scout aircraft these aeroplanes typically required water-cooled engines. Demand for specialist radiators was thus suddenly increased beyond existing capacity. The formerly Norwegian-owned Motor Radiator Manufacturing Co. was taken over directly by the Ministry in January 1918 to meet this need.

Fig. 4.41. National Radiator Factory Greet, the Motor Radiator Manufacturing Co. works at Greet, Birmingham (later Serck Radiator Co.), air photograph, 1935 (© Historic England EPW048061).

The company owned two factories, their principal works at Greet, near Birmingham, and a subsidiary factory at Sudbury in Suffolk (Fig 4.41). The Greet factory employed around 450 people at its peak and was capable of producing 600 radiators per month, while Sudbury was much smaller, with a maximum of 150, and at times as few as 30 employees. The Sudbury works also focused on repairing damaged radiators returned from the RFC in France. Both factories are shown on wartime Ordnance Survey maps, and would appear to have been existing pre-war factories. After the war the two factories were returned to their former Norwegian owner, who

renamed the company after himself as the Serck Radiator Co.[154] Air photography of the Birmingham factory survives from 1935 but it is not known to what extent this incorporates post-war construction. Both factories have since been largely demolished, but one building does survive on Radiator Road, Sudbury, which appears to have been part of the smaller factory (see Appendix B). This consists of a long, single-span brick-built factory building, but no information about its internal arrangements has been uncovered.

National Timber Drying Kilns

As was discussed earlier, aircraft production required large quantities of seasoned ash timber. This was the same material used in railway carriage construction so it was a natural choice for the Ministry of Munitions to negotiate with two railway companies who already owned carriage workshops, to construct drying kilns, which in turn would serve the two companies' needs after the war. Two National Kilns were constructed, at the GWR workshops in Swindon, and at the LB & SCR workshops at Lancing, Sussex.[155] These facilities used steam to dry out batches of sawn timber, and were supplied by the existing sawmills and timber yards at both sites. However it has not been possible to identify the exact location of these plants.

A description of a 'typical' timber drying kiln was given in *The Builder* in 1919.[156] Here a brick building was described 93ft long and 25ft wide with a Belfast truss roof. This was divided longitudinally into two kilns. Each consisted of a set of gently inclined railway tracks, accessed by porches protected by an overhanging roof at either end. The ends were sealed by canvas curtains. Wood would be fed in at the higher end on a series of trolleys, which would pass through under gravity as treated wood was removed from the lower end. Inside a high temperature and humidity was maintained by heating coils and humidifiers. In theory the temperature and humidity was increased along the length of the kiln so that the wood dried gradually and did not warp or crack. Steam heat was provided by static locomotive boilers in a separate boiler house, fuelled with sawdust from the adjacent sawmill. Each load of wood would take about ten days to pass through the kiln.

4.7 CHEMICAL AND ANTI-GAS FACTORIES

Purpose

Prior to 1918, all of the UK requirement for chemical agents was met by private contractors. Up to that point the British forces had principally been using chlorine and phosgene as lethal agents, as well as various lachrymatory compounds. One of these existing chlorine and phosgene plants; that of Electro Bleach & By-Products Ltd, Middlewich, was nationalised in August 1918 in order to boost unsatisfactory levels of production. The gas cylinder salvage depot at Bucknall in Staffordshire was also brought under Ministry control in 1917 in an attempt to increase efficiency and overcome safety problems.[157]

In April 1918, production of chemical warfare supplies was transferred to the Explosives Supply Department. This reflected the fact that this department was responsible for the chemical works currently used to manufacture explosives, and it was hoped that capacity could be found within those factories for manufacturing chemical weapons.[158] 1918 also saw a shift in chemical warfare towards vesicant agents such as mustard gas (HS). This had first been used by the Germans in 1917 but the technology was quickly copied by the Allies. Manufacturing facilities for mustard gas were established at the former picric acid factory at HMEF Avonmouth, with filling carried out at Chittening, and later at the filling factories at Hereford and Banbury (discussed previously in sections 4.2 and 4.4). To support this work an additional plant was built in spring 1918 at CWF Langley, near Birmingham for the production of carbon tetrachloride. This was used as a solvent for the production of mustard gas.[159]

In addition to work on mustard gas, research into other agents continued, and production began of what the official *History* describes as 'arsenic compounds'. These are likely to have been diphenylchloroarsine, also known as 'Adamsite', which was essentially a toxic smoke, and ethyldichloroarsine which was a vesicant agent with effects similar to mustard gas. In the event, neither of these agents was deployed on the battlefield by the Allies as production did not reach sufficient scale before the Armistice. Again former picric acid factory sites were used for this work, at HMEF Sutton Oak, and HMEF Ellesmere Port. In the summer of 1918 a formerly private chemical works, the South Metropolitan Gas Company at Rainham in Essex, was also taken under Ministry control and converted to arsenic work.[160]

Protection measures against gas attack were also required, and again most gas mask and respirator production was contracted out to private firms. Some work was, however, carried out in government factories. The former LCC stores depot at Stamford Hill in London was acquired by the Ministry in 1916 and converted to produce filter granules for respirators. Two mills in Holloway, Batavia Mills, and Holloway Mills, were also opened in 1918 as Anti-Gas Factories, manufacturing 'Green Band' respirators.[161]

Factory Characteristics

Chemical Warfare Factories

CWF Middlewich was created by the nationalisation of Electro-Bleach & By-Products Ltd (Fig 4.42). This company was originally established as the Electrolytic Alkali Co. in 1899, and was reorganized and re-established as Electro-Bleach & By-Products Ltd in 1914. As it was in the business of producing chlorine-based bleaches, the production of gaseous chlorine would have been appropriate to this factory. After the war the factory was bought by Brunner, Mond & Co. Ltd in 1920, and closed in 1928.[162] The factory has now been demolished, but coincidentally an image of the interior survives as *The Engineer* ran a photo feature on the electric generators installed in the plant in 1915.[163]

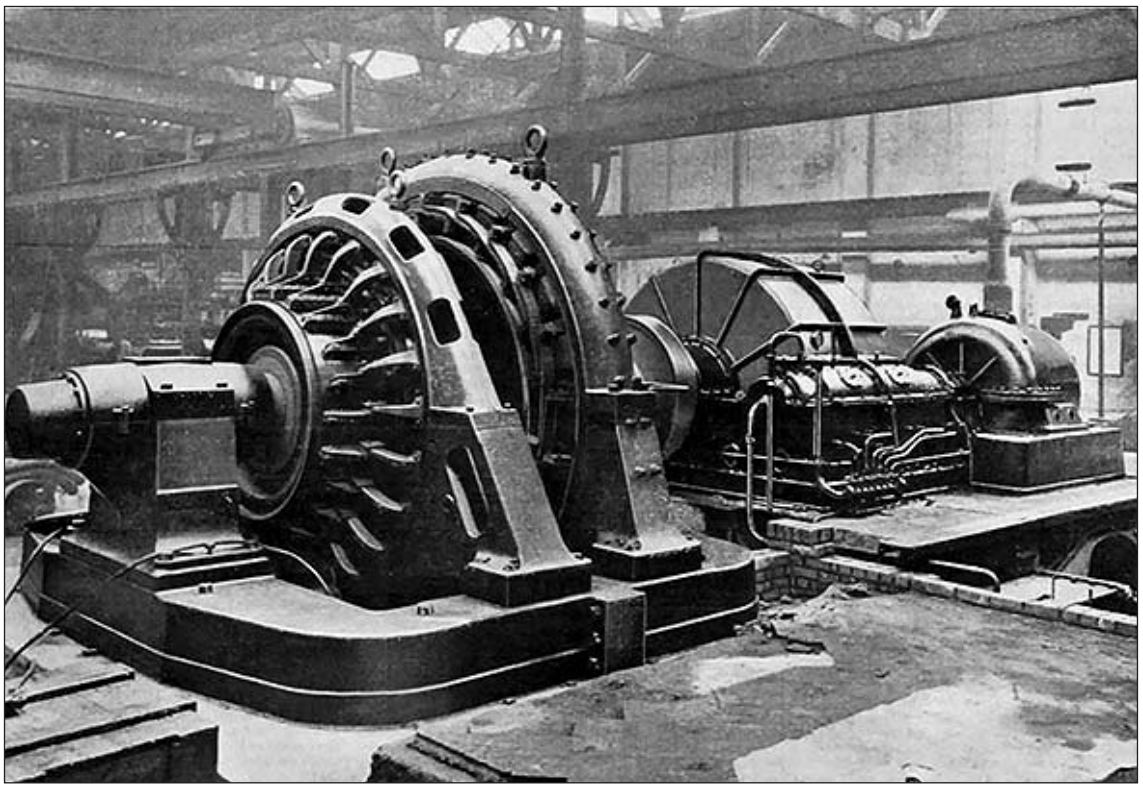


*Fig. 4.42. CWF Middlewich; interior showing generator (*The Engineer *December 1915).*

This image does not provide much information on the process of chlorine gas production but a sense of the interior scale of the works can be gained from it. It is striking that even at the start of 1916 little concern seems to have been shown for wartime industrial security, with the factory named and described in the magazine. Later 1917 and 1918 editions of the magazine would be much more circumspect in describing industrial facilities.

The features of the former picric acid factories, and filling factories converted to mustard gas production and filling, have been described in the earlier sections. Little information has been uncovered concerning the smaller plants at Langley

(Birmingham), Rainham (Essex) and Bucknall (Staffordshire). All have been demolished, as would be expected of buildings potentially contaminated by chemicals, and the exact location of the factory at Rainham is uncertain. Information concerning the South Metropolitan Gas Co. has been identified, but no reference could be found to a factory at Rainham in particular. Some sources suggest that 'poison gas' was produced at the soap works next to Rainham Creek.[164] This would make sense, as the coal tar industry would have provided suitable technology for both civilian combustible gas, soap, and other chemical processes. This factory was probably in the vicinity of the explosives works which was also nationalised as HMEF Rainham, the whereabouts of which is also uncertain.

Anti-Gas Factories

The two respirator factories in Holloway, Batavia and Holloway Mills, were taken over from Betts & Co. Both buildings had been in use since the 1870s for the manufacture of packaging of various kinds, including lead work for the lining of tea chests, and collapsible tubes (i.e. 'toothpaste tubes') for medicines and other products. Both of these mills still stand (see Appendix B), and Holloway Mill is currently occupied by an acting school.

4.8 MISCELLANEOUS NATIONAL FACTORIES

Purpose

In addition to the more obvious functions of manufacturing propellants and explosives, and casting, turning, and filling shells, National Factories were employed on a wide range of other tasks. Firstly, there were the gauge and tool factories. These were required to produce gauges so that the vast numbers of contractors for different munitions produced items to standard dimensions and tolerances. Secondly, there were the factories for repair and rectification. Large quantities of munitions of all types were returned from the fighting front, either because they were found faulty and needed repair, or they were salvaged for reprocessing into new items. Also within this category were the National Box Factories. The huge amounts of munitions produced required boxes and crates of all kinds for transportation. In many cases these boxes could be returned, and then were assessed for repair where necessary before being sent for refilling and despatch once again to the Front. The manufacture of all these boxes also required supply of suitable timber and board, resulting in the nationalisation of a number of sawmills. Finally, there were a few factories engaged in specific and unusual tasks such as the optical munitions factories, the National Machine Gun Factory, or those producing concrete slabs. Each is considered in more detail in the following sections.

Factory Characteristics

National Gauge and Tool Factories

Three National Gauge Factories were established in 1915, at Woolwich, Birmingham, and Croydon. All of these were created as extensions to existing engineering firms, and arrangements were made for the Ministry to direct operations, although the financial arrangements with each firm 'varied considerably'.[165] Two further factories were taken over, at the Wolseley Motor Co. in Pimlico in 1917, and Newall Engineering in Walthamstow in 1918. A further small factory was created at Kilburn in 1917 and this was staffed by enemy internees. All of these factories were on a small scale in comparison to some of the other National Factory groups, and most occupied existing premises. A surviving example is the NGF Birmingham, housed in Victoria Works, owned by Chatwins, which consists of a series of 19th-century brick workshops around a central yard (see Appendix B). Some new building did take place, and at Walthamstow historic map evidence suggests that a large factory building on Black Horse Lane, later converted into a dyeing and cleaning works, is of wartime construction, and was formerly NGF Walthamstow (Appendix B).

Three specialist National Tool Factories were also created. Only one of these was a new establishment, a factory in Gateshead dedicated to producing spade-cutters. These were the cutting tools used to machine the interior of shell castings, and were required in large numbers. The factory produced up to 3,000 per week. The other two factories were in existing firms: the Coats Machine Tool Co. in Westminster, which produced various small tools, and Hoffman Manufacturing in Chelmsford, which produced ball bearings.[166] Part of this latter factory is still extant (see Appendix B), the surviving buildings now being part of Anglia Ruskin University (Fig 4.43).

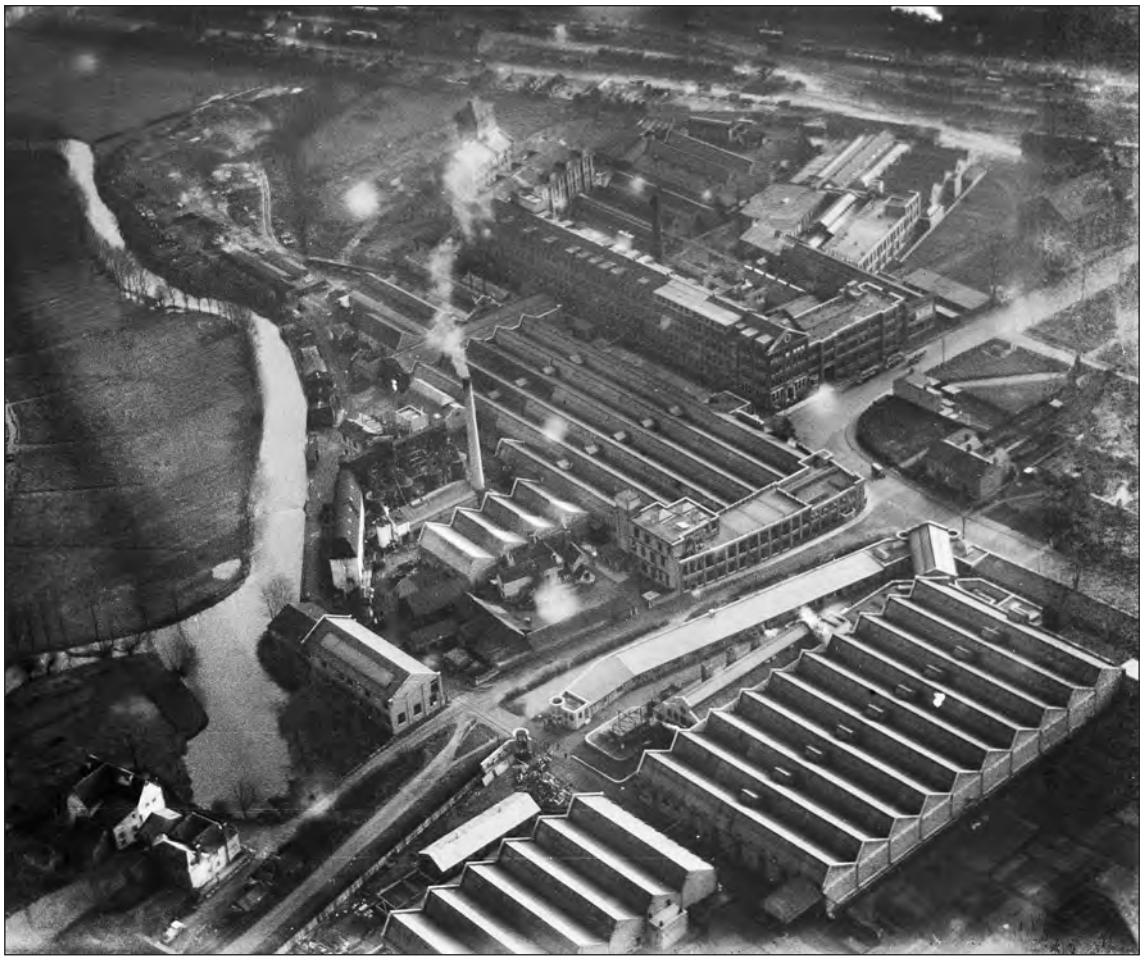


Fig. 4.43. National Ball-Bearing Factory Chelmsford, formerly Hoffman's, air photograph 1923 (© Historic England EPW009600).

National Factories for Salvage Repair and Rectification

The salvage repair and rectification factories were principally concerned with the re-use of fired brass cartridge cases and their boxes, and the rectification of fuses. Material was imported via the five Government Salvage Depots in the ports of Blyth (Northumberland), Immingham (Lincolnshire), Ridham (Kent), Trafford Park (Manchester), and Renfrew in Scotland. These were very simple establishments, in many cases just open yards with indoor space limited to temporary huts. As a result it has not been possible firmly to identify the locations of these depots within the ports concerned. The salvage was then passed on to specialist plants. 18pdr and 4.5-inch cartridge cases were sent along with their boxes to the National Cartridge and Box Repair Factories at Dagenham (Essex) , and Newport in Wales. By the spring of 1917 these two sites were repairing 650,000 18pdr and 100,000 4.5-inch cases per week along with 175,000 ammunition boxes. Bomb and grenade boxes went to the box repair factory run by the Trench Warfare Department at Beddington near Croydon, which repaired 15,000 boxes per week in 1917. Meanwhile the carriages from the guns themselves were repaired in Southampton at the National Gun Carriage Repair Factory at Empress Road.[167] All of these factories have now either been demolished, or it was not possible to identify their precise locations, so it is not possible to provide further detail about their individual character.

National Box Factories and Sawmills

In addition to recycling old boxes, there was also huge demand for new ones. Contracts were placed with existing firms but by 1916 a number of National Box Factories were also in operation. By October 1917 ten had been opened. Mostly these were working with wood but there was a requirement in some cases for metal-lined boxes, and so specialist factories were opened. The first was at Deptford, south London, but later factories at Maidstone, Guildford, and Luton were also engaged in 'Tin Box' work. Supplies of timber for these factories came from a number of sources. QF ammunition boxes were generally made from imported timber, but in 1917 steps were taken to exploit domestic supplies for other types of box. By the time of the Armistice, seven National Sawmills were in production in England, with a further six in Scotland. All of these were located at pre-existing sawmill companies.[168]

No surviving structures associated with National Box Factories and Sawmills have been identified during this study. Most appear to have been demolished, or the exact locations remain uncertain. In one case, however, the company nationalised in 1917 would appear to have survived to the present. A timber yard belonging to Messrs J. T. Sydenham & Co., a firm described in the official *History*, is shown on the 1890, 1902 and 1925 OS maps just to the north of Hamworthy Railway Station on Blandford Road, Poole, in Dorset. This seems to be the likely position for the First World War sawmill. There is still a sawmill at the same location, owned by Sydenhams Group, a company founded in 1874.[169] While the site is likely to be that of the National Factory, it is not known whether any features survive from the First World War period.

Mine Sinker Assembly Station

Early in 1917 the Trench Warfare Department of the Ministry took up a demand from the Admiralty for mine sinkers. These were the lower portion of naval mines, which sat on the sea bed with a mine attached above by a cable. Production of the various components was achieved by sending out contracts to a group of manufacturers, but a central location for assembly of the finished sinkers was required. An empty building was identified at W R Morris Motors Ltd in Cowley, Oxford (Fig 4.44). This had been constructed immediately before the war, and was a steel framed three-bay factory, with north-light roofs and clad with corrugated iron.[170] This was rented, and fitted out by the Ministry as the Mine Sinker Assembly Station. Eventually 750 sinkers per week were being produced by a workforce of just over 400.[171] The original Morris factory in Cowley survives and is designated a Grade II listed building (see Appendix B), but the additional building used as the mine sinker factory has been demolished.

National Machine Gun Factory

In the autumn of 1917 it became clear that in 1918 demand for machine guns was likely to outstrip supply. This problem was exacerbated by the need for guns to equip large numbers of aircraft and tanks. The construction of a National Factory for this purpose was sanctioned by the Treasury in October 1917, and land was acquired

Fig. 4.44. Mine Sinker Assembly Station Cowley, housed in the W R Morris works, air photograph 1930 (© Historic England EPW031331).

at Branston, near Burton-on-Trent. A substantial series of factory buildings was constructed during 1918, including a three-storey brick administration building, canteens and a large steel-framed factory. In the event the Armistice was signed before any machine guns had been produced, and after some discussions over the viability of keeping the factory open, it was closed and put up for sale in 1919. [172]

The factory was acquired in 1921 by Crosse & Blackwell, and is best known as the birth-place of 'Branston' pickle (Fig 4.45). However pickle was only manufactured there for a short period as production was moved to London in 1924 and the factory was sold on again in 1927.[173] The principal factory block has been demolished but the office and canteen survive and are designated Grade II listed buildings (see Appendix B).

National Factories for Optical Munitions

Prior to the outbreak of war, very few firms in the UK were in the business of optical equipment manufacture. Most supplies were imported from countries such as Switzerland and Germany. The Ministry largely depended for supplies of sighting telescopes and other optics on the Periscopic Prism Co. and their factory at Kentish Town, north London. This company remained in private hands until 1918, when significant expansion to the works was required. In order to achieve this, the Ministry bought out the stock of the company and took it into government

Fig. 4.45. National Machine Gun Factory Branston (Burton on Trent), air photograph 1927, showing the three-storey office complex (centre) and canteen (lower right) (© Historic England EPW019682).

ownership. Nonetheless the plant remained small, employing just over 200 people. A National Photographic Lens factory was also established in 1918 at Brimsdsown near Enfield. This produced lenses for aircraft cameras of various types.[174] Neither factory survives as both sites have been redeveloped

National Concrete Factories

The construction or expansion of a whole series of National Factories in 1918 led to a demand for building materials which could be quickly erected. This problem as solved by the use of plaster and concrete slabs, which could be supported on timber or steel frames. There was also demand for ferro-concrete fence posts and overhead cable poles. Two plants were established to cope with this demand at Gotham in Nottinghamshire and at Yate near Bristol. Both of these factories have been demolished, and no information about their particular character has been identified.[175]

Steel Billet Breaking Factory

The National Steel Billet Breaking Factory was established in 1916 adjacent to the Manchester Ship Canal in Trafford Park. The function of the factory was to take in steel imported from the USA via Liverpool, and break it into short bullets suitable for delivery to shell forging factories. At the same time quality control checks were carried out on the steel. Up to 7,000 tons of steel was processed each week.[176] No specific location, or any other information about this factory has been identified in the course of this study.

National Rifle Factory

In 1918 the War Office decided to adopt a new semi-automatic rifle for the British Army. This was the Farquhar-Hill rifle, a weapon originally designed in 1908 but which had subsequently undergone a series of design refinements to make it suitable for front line use. An order was placed for 100,000 weapons, and to produce these two National Rifle Factories were established. NRF No.1 occupied the former Standard Small Arms Company works in Lench Street in Birmingham, while NRF No.2 was at W Greener's factory in nearby Garrison Lane. In the event the low likelihood of getting the weapons into service before 1919 led to the cancellation of the contracts in October 1918 and no rifles were produced.[177] Neither factory survives as both areas have been redeveloped.

5. SITE SURVIVAL

Some visible physical elements survive at 46 out of the 174 sites of First World War National Factories in England. At many sites one or more buildings are still standing, while at other factories earthworks alone mark where buildings previously stood. It is probable the below-ground archaeological deposits associated with many more sites are also present, however the investigation of possible buried remains was beyond the scope of this assessment. Table 5.1 shows those sites where some visible remains survive, and in each case an indication is given of the origin of these structures, whether wartime or earlier, and the degree to which the remains represent a largely complete factory or building, or only partial fragments. Where these sites have received any statutory designation (listing or scheduling) this is also shown. In addition, Appendix B gives detailed individual information concerning each of these sites. Those sites where structures and features do survive fall into a series of groups, with differing levels of preservation in each case.

Pre-1914 munitions buildings

A significant stock of buildings and other features which were used as parts of National Factories survives at pre-war munitions sites. This is particularly the case at the Royal Ordnance Factories at Woolwich, where more than 50 pre-1914 buildings have been identified, and most, if not all, of these would have been put to use as part of the National Factory programme. However, as these buildings also continued in use post-1918, few features survive which can be positively associated with their use during the First World War. As has been discussed in section 4.1, a number of additional wartime buildings were erected, but these were all on the eastern part of the site which has now been entirely redeveloped and nothing survives above ground in this area.

A similar situation prevails at RSAF Enfield. Here, too, significant parts of the 19th-century factory have been preserved, and these would have been in use during the First World War, but little specific evidence of this period of use is identifiable. The surviving structures at RGPF Waltham Abbey, on the other hand, include large parts of the earlier 19th-century factory, but also additional buildings constructed during the First World War. The context of these more ephemerally constructed wartime buildings is significantly enhanced by their relationship with the adjacent earlier buildings, and as a result a very complete picture of the processes carried on there can be discerned on the site.

Pre-1914 buildings adopted as National Factories

Pre-war buildings built for other, non-munitions, purposes were also put to use temporarily as National Factories. These buildings have survived at a number of sites, either because after the war they returned to their former purpose, such as car and aircraft factories, tram depots or cotton mills, or because having been built at leisure during peacetime they were of sturdy construction or significant architectural merit. Buildings of this type form a significant proportion of the surviving stock of national factory buildings. As a consequence of their location within this category

of buildings, remains of National Shell Factories dominate this group of survivals. Examples include the tram sheds at Manchester and Rochdale and the factory buildings at Cunard's works in Liverpool. Unfortunately, as with the pre-war munitions buildings described above, their wartime use often only led to superficial changes to the structure, or simply the installation of machine tools, and what little evidence of this activity remained after 1918 has often been obscured by later use. As a result the heritage significance these buildings typically has little to do with their First World War function.

1914-18 Purpose-built structures

Purpose-built wartime factory buildings also survive. Inevitably, those which have been preserved tend to be those which were both most solidly built, and amenable to re-use for other purposes after the war. As a consequence, the larger open plan factories and forges constructed as part of the National Projectile Factory programme are quite well represented, for example at Birtley or Templeborough. Similarly the larger buildings at National Filling Factories, such as empty- and filled-shell stores at Chilwell or Hereford, have survived at several sites. In addition where office buildings with a degree of architectural adornment were constructed, these have often been reused and preserved. Sadly, a number of these, such as Avonmouth and Longtown, have recently been demolished.

Much of the activity at National Factories, however, took place in simple wooden huts or temporary buildings constructed of other materials. Surviving examples of these structures are much rarer. Often these buildings were either simply demolished, or sold off for their component materials very soon after the war. As many of these buildings were used for the handling of explosives, contamination was also a factor complicating their reuse. More recently the recognition of the dangers of the large amounts of asbestos used in their construction has also tended to lead to their demolition. Very few wartime timber buildings survive. One unusual example is the hut acquired from NFF Banbury and re-erected in Banbury town as a coffin store for J M Humphris undertakers (Fig 5.1). This building survives several miles from its original location, and installed at first-floor level. It is probable that other buildings were removed from their original sites and re-erected elsewhere, but tracking down these structures is very difficult and beyond the scope of this assessment.

Housing

A very significant quantity of housing was constructed for the accommodation of workers at National Factories. The post-war housing shortage meant that many of these homes continued to be occupied after the conflict. Estates such as that at Well Hall or Gretna were also built to quite high architectural and construction standards, and have become more desirable as housing with the passage of time. The result of this is that, in the case of Well Hall, the estate survives substantially complete. At a number of other sites where mass housing was not provided, cottages were nonetheless erected for particular members of staff: police, night watchmen and foremen, for example. These isolated dwellings have often survived where the former factories have been demolished. At other sites, although mass housing

Fig. 5.1. NFF Banbury, former timber-framed factory building in use as coffin store, 1990 (R. Kinchin-Smith).

was constructed, it consisted only of temporary wooden structures. This was lived in post-war but has progressively been demolished. The last of over 800 wooden accommodation huts at Gretna has recently been replaced by a modern bungalow, and all that survives of the over 850 wooden houses at the 'Elizabethville' Belgian village at Birtley are two shop buildings (see Appendix B). As with the factories themselves, it is only the more permanently built parts of these sites which survive.

Earthworks and other remains

In addition to surviving buildings, the sites of a number of former National Factories are discernible through earthworks and other archaeological features. The protective earth bunds built around explosives-handling buildings have survived in locations where the buildings themselves have been demolished. This is the case at Banbury. (Earth bunds have also survived along with their internal buildings at Smalmstown, Gretna, and Hereford). Similarly the rail lines constructed at a several sites are discernible as embankments and cuttings, from which the track itself has long been removed. Banbury is also an example of this, as well as Leeds (Barnbow) and Gainsborough. More ephemeral remains also occur, such as the crop marks of the former rail lines visible at Bootle, and areas of poor crop growth, or differential weed growth resulting from ground contamination, seen at Gainsborough and Banbury. Parch marks probably reflecting the former NPF Hackney Marshes are also apparent on air photographs in Mabley Green Park, suggesting the survival of below-ground remains. There is no doubt that beyond these visible traces, a variety of buried archaeological remains survive at these sites, as well as many others. At the time of writing very little formal archaeological investigation of these sites has occurred.

Table 5.1 List of surviving National Factory Buildings and Structures.

Type	Location	Surviving Structures	Origin	Designated?	Extent
ROF	Woolwich	Over 50 different structures	Pre-existing	Gr II and II*	Complete
RSAF	Enfield	Factory and office buildings	Pre-existing	Gr II	Complete
RGPF	Waltham Abbey	Factory buildings	Pre-existing and purpose-built	Gr I and II	Complete
HMEF	Gretna	Stores, housing	Purpose built		Complete
	Swindon	Stores and guardroom	Purpose built		Partial
Acetone	Ludlow	Factory sheds	Purpose built		Partial
Cotton Waste	Greenfield	Mill buildings	Pre-existing		Complete
	Hadfield	Mill buildings	Pre-existing		Partial
	Rawtenstall (Constable Lee)	Mill buildings	Pre-existing	Gr II	Complete
	Rawtenstall (Holme Mill)	Earthworks and mill-leat	Pre-existing		Partial
	Woodley	Mill buildings	Pre-existing		Partial
NSF	Birmingham	Factory sheds	Some new-build		Partial
	East Cumberland	Drill hall porch and canteen	Pre-existing		Partial
	Leeds NFF	Factory sheds	Pre-existing		Complete
	Liverpool (Cunard)	Factory sheds	Pre-existing		Partial
	Manchester	Tram depot	Pre-existing		Complete
	Metropolitan (Ailsa Craig)	Factory sheds	Pre-existing		Complete
	Rawtenstall and Bacup	Mill building	Pre-existing		Complete
	Rochdale	Tram depot	Pre-existing		Complete
NPF	Birtley	Factory sheds Village shops	Purpose-built		Complete
	Dudley	Factory sheds	Purpose-built		Complete
	Sheffield (Templeborough)	Factory sheds	Purpose-built		Partial
	NOF New Basford	Factory sheds	Pre-existing		Complete

Type	Location	Surviving Structures	Origin	Designated?	Extent
NFF	Banbury No. 9	Earthworks, hut (not in situ)	Purpose-built	Scheduled	Partial
	Chilwell No. 6	Factory sheds	Purpose-built		Partial
	Coventry No. 10 & 21	Factory sheds	Purpose-built		Partial
	Gainsborough No.22	Earthworks	Purpose-built		
	Hereford No. 14	c. 30 structures	Purpose-built	Gr II	Partial
	Leeds No. 1	Earthworks	Purpose-built	Scheduled	
	Liverpool No. 2	Crop mark	Purpose-built		
	Morecambe No. 13	Electric plant	Purpose-built		Partial
TWFF	Walthamstow	Factory sheds	Purpose-built		Partial
GCF	Blackpole	Factory sheds	Purpose-built		Complete
RAF (RAE)	Farnborough	Offices, hangars	Purpose built	Gr II and II*	Partial
NAF	Heaton Chapel	Factory sheds	Purpose-built		Partial
NA-EF	Ladbrooke Grove	Offices	Pre-existing	Gr II	Partial
	Hayes	Factory sheds	Pre-existing		Complete
NRF	Sudbury	Factory sheds	Purpose-built		Partial
AGF	Holloway (Batavia)	Mill building	Pre-existing		Complete
	Holloway (Holloway)	Mill building	Pre-existing		Complete
NGF	Birmingham	Factory sheds	Pre-existing		Complete
	Walthamstow	Factory sheds	Purpose-built?		Complete
NTF	Chelmsford (Ball-Bearing)	Factory and offices	Pre-existing		Partial
Sawmill	Poole	Factory sheds	Pre-existing		Partial
MSAS	Cowley	Factory and offices	Pre-existing	Gr II	Partial
NMGF	Burton-on-Trent	Offices and canteen	Purpose-built	Gr II	Partial

ENDNOTES

[1] Ministry Of Munitions, 1918, *Directory of Manufacturers in the Engineering and Allied Trades* (HMSO London)

[2] Ministry of Munitions, 1922, *History of the Ministry of Munitions Vol. VIII, Pt II*, 'The National Factories' (HMSO London) Appendix IV

[3] Simmonds, A, 2013, *Britain and World War One* (Routledge, Abingdon), p. 67

[4] Cocroft, W D, 2000, *Dangerous Energy The archaeology of gunpowder and military explosives manufacture* (English Heritage, Swindon), p. 155

[5] Fraser, P, *'The British "Shell Scandal" of 1915' in The Canadian Journal of History,* Vol 18 Pt 1, 1983, (University of Toronto Press, Toronto), p. 75

[6] Simmonds, 2013, p. 69

[7] Fraser, 1983, p. 69

[8] The term 'Push and go' is widely attributed to Lloyd George, speaking in the House of Commons in March 1915, however the only remark of this nature recorded in Hansard is as follows,

> 'We are on the look out for a good, strong business man with some go in him who will be able to push the thing through and be at the head of a Central Committee.'

http://hansard.millbanksystems.com/commons/1915/mar/09/defence-of-the-realm-amendment-no-2-bill (accessed 3/2/2015)

[9] Simmonds, 2013, p. 72

[10] http://www.nationalarchives.gov.uk/pathways/firstworldwar/britain/p_munitions.htm (accessed 13/8/14)

[11] Simmonds, 2013, p. 70

[12] Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* Vol. VIII, Pt II, 'The National Factories', (HMSO, London) p. 1

[13] Ministry of Munitions, 1920-23, Appendix IV

[14] Bennett, T, 1916, 'Temporary buildings for war purposes', *The Builder*, 21st January 1916, p. 70

[15] Baines, F, 'War Factories and Sheds – Their construction and Adaptation to Future Needs', *Journal of the Royal Institute of British Architects,* Vol XXVI, August 1919, (RIBA London)

[16] Anon, 'A National Projectile Factory' offprint from *The Engineer*, July 1916, TNA MUN5/157, p.12

[17] Anon, 1916, p.14

[18] Bennett, T, 1916, p. 71

[19] Buckland, H, 'Some Essentials of Factory building' Paper delivered to the Royal Sanitary Institute Annual Congress reported in *The Builder,* 6th August 1920, p.158

[20] Buckland, H, 1920 p.159

[21] Buckland, H, 1920.159

[22] http://www.ford.co.uk/experience-ford/Heritage/EvolutionOfMassProduction (accessed 24/02/2015)

[23] Ministry of Munitions, 1920-23, Vol. VIII, Pt II, p. 210

[24] Johnson, A, 'Homes for war-workers' in *IHBC Journal*, No. 137, November 2014, p. 25

[25] Cocroft, 2000, p. 185

[26] Cocroft, 2000, p.185

[27] Ministry of Munitions, 1920-23, Vol VIII Pt II, p. 135

[28] Edmonds, J, 2004, *The History of Rotherwas Munitions Factory Hereford* (Logaston Press, Hereford), p. 16

[29] http://www.disused-stations.org.uk/c/chaul_end/ (accessed 12/01/2015)

[30] Baines, 1919, pp.231, 234

[31] Baines, 1919, p.234

[32] Cocroft, 2000, p.186

[33] Edwards, B, 'National Filling Factory No 5 Quedgeley' in *Gloucestershire Society for Industrial Archaeology Journal,* 1994, p. 39

[34] Haslam, J, 2005 *The Chilwell Story, VC Factory and Ordnance Depot* (Second Edition Excelsior, Nottingham) p. 41

[35] Cocroft, 2000, p. 187

[36] Cocroft, 2000, p. 189

[37] Ministry of Munitions, 1920-23, Vol VIII Pt II, p. 183

[38] Buckland, 1920, p. 159

[39] Lloyd George, D, 1938, *War Memoirs of David Lloyd George* (Odhams, London) Vol 1 p. 175

[40] Lloyd George, D, 1938, p. 207

[41] 'Appointment of a Lady Superintendent at Royal Gunpowder Factory', TNA MUN 7/554

[42] 'Appointment of a Lady Superintendent at Royal Gunpowder Factory', TNA MUN 7/554

[43] 'Reports on the employment of women at RSAF and RGPF', March 1917, TNA MUN 5/219B

[44] 'Reports on the employment of women at RSAF and RGPF', March 1917, TNA MUN 5/219B

[45] 'Reports on the employment of women at RSAF and RGPF', March 1917, TNA MUN 5/219B

[46] Cocroft, 2000, p. 190

[47] Pam, D, 1998, *The Royal Small Arms Factory Enfield and its Workers*, (Private pub.), pp.132-134

[48] 'Reports on the employment of women at RSAF and RGPF', March 1917, TNA MUN 5/219B

[49] Johnson, 2014, p. 25

[50] Greenwich Council 2007, Progress Estate Conservation Area Character Appraisal (Pdf viewed at http://www.royalgreenwich.gov.uk/downloads/file/17/progress_estate_character_appraisal_adopted_dec_2007 accessed 20/01/15) p. 10

[51] Saint, A, 1989, 'Spread The People: The LCC's Dispersal Policy 1889-1965' in Saint A (ed.), *Politics and People of London : London County Council 1889-1965,* (Bloomsbury, London) p. 220

[52] Johnson, 2014, p. 26

[53] Stratton, M, and Trinder, B, 2000, *Twentieth Century Industrial Archaeology* (E and F N Spon, London) p. 218

[54] Swenarton, M, 1981, *Homes Fit for Heroes, The Politics and Architecture of Early State Housing in Britain* (Heinemann, London) p. 54

[55] Bennett, T,P, 'Temporary Buildings for War Purposes: II Subsidiary Points of Importance' in *The Builder*, 18 February 1916, p. 143

[56] Bennett, T P, 1916, p. 143

[57] Swenarton, 1981, p. 63

[58] http://canmore.rcahms.gov.uk/en/site/121301/details/eastriggs+65+pretoria+road/ (accessed 20/1/2015)

[59] Cocroft, 2000, p. 191

[60] 'History of the National Projectile Factory Birtley', Typescript ,TNA MUN5/157 pp.57-59

[61] 'History of the National Projectile Factory Birtley', Typescript ,TNA MUN5/157 pp.57-59

[62] 'History of the National Projectile Factory Birtley', Typescript ,TNA MUN5/157 pp.57-59

[63] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 5

[64] See the following reports:

Putnam, T, & Weinbren, D, 1992, *A Short History of the Royal Small Arms Factory Enfield* (Royal Ordnance Plc/Middlesex University)

RCHME (1), *The Royal Arsenal Woolwich, Historic Buildings Report* (Royal Commission on the Historical Monuments of England, 2 Vols, 1994)

RCHME (2), *The Royal Gunpowder Factory, Waltham Abbey, Essex and RCHME Survey 1993* (Royal Commission on the Historical Monuments of England, 2 Vols, 1994)

[65] Ministry of Munitions, 1920-23 Vol. VIII Pt II p. 4

[66] Ministry of Munitions, 1920-23 Vol. VIII Pt II p. 9-10

[67] RCHME (1) 1994 Vol 1, p. 1

[68] Ministry of Munitions, 1920-23, Vol. VIII Pt II, pp. 28-30

[69] Putnam, T, & Weinbren, D, 1992 p. 85

[70] Putnam, T, & Weinbren, D, 1992, Site Plans 4 and 5

[71] Ministry of Munitions, 1920-23 Vol. VIII Pt II p. 32

[72] Putnam, T, & Weinbren, D, 1992, p. 89

[73] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 37

[74] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 37

[75] RCHME (2), 1994, pp. 127-132

[76] Brown, G, 1998, *The Big Bang, A History of Explosives* (Sutton, Stroud), pp. 233-238

[77] Cocroft, 2000, pp. 159-163

[78] See reports:

Bowditch M, R, & Hayward L, 1996, *A Pictorial Record of the Royal Naval Cordite*

Factory Holton Heath (Finial Publishing, Wareham)

RCHME (2), 1994, *The Royal Gunpowder Factory, Waltham Abbey, Essex an RCHME Survey 1993* 2 Vols (Royal Commission on the Historical Monuments of England, London)

[79] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 60

[80] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 83-5

[81] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 86

[82] Brown, 1998, p. 235

[83] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 76

[84] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 54

[85] Brown, 1998, p. 153

[86] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 44

[87] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 55

[88] Brown, 1998, p. 157

[89] Brown, 1998, p. 163

[90] 'History of State Manufactury of Ammonium Nitrate', TNA MUN5 365

[91] Cocroft, 2000, p. 170

[92] Cocroft, 2000, p. 162

[93] 'History of National Wood Distillation Factories', TNA MUN5/365

[94] Correspondence in TNA MUN4/6102

[95] 'Retrospective Review of HM Factory, West Gorton, Manchester', TNA MUN5/368, p. 1

[96] Ministry of Munitions, 1920-23, Vol VIII Pt II, p. 61

[97] Cocroft, 2000, p. 187

[98] Baines, 1919, pp. 220-240

[99] Baines, 1919, p. 220

[100] http://www.suttonbeauty.org.uk/suttonhistory/poisongas.html (accessed 27/11/2014)

[101] Ministry of Munitions 1920-23, Vol VIII Pt II, pp. 49-50

[102] Ministry of Munitions 1920-23, Vol VIII Pt II, p. 57

[103] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 87

[104] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p.88

[105] Ministry of Munitions, 1920-23, Vol. VIII Pt II, pp. 124-125

[106] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 111

[107] 'A National Projectile Factory' Offprint from *The Engineer,* July 1916, TNA MUN5/157, p.7

[108] 'History of the National Projectile Factory Birtley', TNA MUN5/157, p. 14

[109] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 89

[110] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 90

[111] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 108

[112] http://archive.iwm.org.uk/server/show/nav.3202 (accessed 17/02/2015)

[113] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 99

[114] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 112

[115] 'A National Projectile Factory' Offprint from *The Engineer*, July 1916, TNA MUN5/157

[116] 'History of the National Projectile Factory Birtley', TNA MUN5/157

[117] Ministry of Munitions, 1920-23, Vol. VIII Pt II, p. 136

[118] Dudley HER Ref 2732

[119] http://www.iwm.org.uk/history/anna-airy (accessed 14/10/2014)

[120] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 148-149

[121] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp.158-184

[122] Cocroft, 2000, pp. 159-176

[123] 'History of Gloucester National Filling Factory No. 5 Quedgely near Gloucester', TNA MUN5/154

[124] 'History of Gloucester National Filling Factory No. 5 Quedgely near Gloucester', TNA MUN5/154 p.5

[125] NFF No. 1 Leeds, plan: West Yorkshire Archaeology Advisory Service, NFF No. 2 Liverpool plan, TNA MUN5/157

[126] 'History of NFF No.5 Banbury and description of various filling processes', TNA MUN5/155

[127] Edmonds, J, 2004, p. 18

[128] Ministry of Munitions 1920-23, Vol. VIII Pt II p. 152

[129] Cocroft, 2000, p.176

[130] Edmonds, 2004, p. 31

[131] Haslam, J, 2005, pp. 12-15

[132] Ministry of Munitions, Undated 'A Short History of National Filling Factory No. 7 Hayes, Middlesex (Harrison and Sons, Hayes), TNA MUN5/154 p.3

[133] IWM image Q30151

[134] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 154

[135] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 157

[136] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 184

[137] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 183

[138] Cocroft, 2000, p. 181

[139] 'History of No. 23 NFF Chittening (Chemical Shell)' TNA MUN5/154

[140] 'History of N.F.F. No.5 Banbury and description of various filling processes', TNA MUN5/155

[141] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 185-191

[142] TNA MUN4/216

[143] 'Option to Purchase Govt Cartridge Factory No.4 Edmonton', TNA MUN4/216

[144] http://1914-1918.invisionzone.com/forums/index.php?showtopic=120277 (accessed 04/11/2014)

[145] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 190

[146] 'The Government Rolling Mills Southampton' in *The Engineer*, 28 Feb 1919 pp.191-2

[147] 'The Government Rolling Mills Southampton', p. 187

[148] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 39-40

[149] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 197-198

[150] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 213

[151] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 206

[152] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 208-209

[153] http://www.theatrestrust.org.uk/search?page=13&q=demolished&type=theatre (accessed 11/11/2014)

[154] http://www.serck.com/history.html (accessed 11/11/2014)

[155] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 213

[156] Baines , 1919, p. 648

[157] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 229

[158] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 226-227

[159] Ministry of Munitions 1920-23, Vol. VIII Pt II, pp. 226-227

[160] Ministry of Munitions 1920-23, Vol. VIII Pt I, pp. 226-227I

[161] Ministry of Munitions 1920-23, Vol. VIII Pt II p. 229

[162] http://discovery.nationalarchives.gov.uk/details/rd/82bf9e06-8dc8-4c68-93d7-ace1c2980a1e (accessed 27/11/2014)

[163] *The Engineer,* 31 December 1915, p. 626, http://www.gracesguide.co.uk/images/a/ae/Er19151231.pdf (accessed 27/11/2014)

[164] http://www.british-history.ac.uk/report.aspx?compid=42827 (accessed 27/11/2014)

[165] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 214

[166] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 216

[167] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 218

[168] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 220

[169] http://www.sydenhams.co.uk/ (accessed 2/12/2014)

[170] Collins, P, and Stratton, M, 1993, *British Car Factories from 1896, A Complete Historical Geographical Architectural and Technological Survey* (Veloce), p. 146

[171] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 222

[172] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 223

[173] http://www.burton-on-trent.org.uk/category/surviving/branston-depot/branston-pickle (accessed 2/12/2014)

[174] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 224

[175] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 225

[176] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 225

[177] Ministry of Munitions 1920-23, Vol. VIII Pt II, p. 231

6. BIBLIOGRAPHY

Archival Sources

'Appointment of a Lady Superintendent at Royal Gunpowder Factory', TNA MUN7/554

Correspondence (re. Ludlow) in TNA MUN4/6102

Correspondence (re. Bideford) in TNA MUN4/6053

'History of Gloucester National Filling Factory No. 5 Quedgely near Gloucester', TNA MUN5/154

'History of Morecambe National Filling Factory', TNA MUN5/154

'History of National Wood Distillation Factories', TNA MUN5/365

'History of NFF No.9 Banbury and description of various filling processes', TNA MUN5/155/1122.3/51

'History of No. 2 Filling Factory Aintree Liverpool', TNA MUN5/155

'History of No 14 National Filling Factory Hereford', TNA MUN5/154

'History of No. 23 NFF Chittening (Chemical Shell)', TNA MUN5/154

'History of the National Projectile Factory Birtley', TNA MUN5/157

'History of State Manufactury of Ammonium Nitrate', TNA MUN5 365

'Option to Purchase Govt Cartridge Factory No.4 Edmonton', TNA MUN4/216

'Photographs of Coventry No 10 (Now No 21) Filling Factory January 1916', TNA MUN5/157

'Photographs Morecambe National Filling Factory December 1915', MUN5/157

'Photographs of No 1 Leeds National Filling Factory November and December 1915', TNA MUN5/157

'Photographs of No.2 Filling Factory Liverpool December 1915', MUN5/157

'Policy re disposal of H M Wood Distillation factories at Bideford, Coleford, Longparish, Ludlow and Mid-Havant', TNA MUN4/6187

'Report of the Coventry National Filling Factory 1915-1918', TNA MUN5/155,

'Reports on the employment of women at RSAF and RGPF', March 1917, TNA MUN5/219B

'Report on the work carried out at HM Factory Walthamstow during the War (1914-1918)', TNA MUN5/368

'Retrospective Review of HM Factory, West Gorton, Manchester', TNA MUN5/368

Published Sources

Anon, '1250-K.W. Turbo-Alternator At a Chemical Works' in *The Engineer*, 31 December 1915 p. 626, http://www.gracesguide.co.uk/images/a/ae/Er19151231.pdf (accessed 27/11/2014)

Anon, 'A National Projectile Factory' Offprint from *The Engineer,* July 1916, TNA MUN5/157

Anon, 'The Government Rolling Mills Southampton' in *The Engineer* 28 Feb 1919, pp. 191-193

Baines, F, 'War Factories and Sheds – Their construction and Adaptation to Future Needs' in *Royal Institute of British Architects Journal*, Vol XXVI, August 1919 (RIBA London), pp. 230-240

Bennett, T, 'Temporary buildings for war purposes' in *The Builder* 21st January 1916, pp.69-71

Bennett, T, 'Temporary Buildings for War Purposes: II Subsidiary Points of Importance' in *The Builder*, 18 February 1916, pp. 143-145

Bowditch M, & Hayward L, 1996, *A Pictorial Record of the Royal Naval Cordite Factory Holton Heath* (Finial Publishing, Wareham)

Brown, G, 1998, *The Big Bang, A History of Explosives* (Sutton, Stroud)

Buckland, H, 1920, 'Some Essentials of Factory building'. Paper delivered to the Royal Sanitary Institute Annual Congress reported in *The Builder,* 6 August 1920, pp. 158-160

Cocroft, W D, 2000, *Dangerous Energy the archaeology of gunpowder and military explosives manufacture* (English Heritage, Swindon)

Cocroft, W D and Leith, I, 1996, 'Cunard's Shellworks, Liverpool', *Archive 11*, 53-64

Collins, P, and Stratton, M, 1993, *British Car Factories from 1896, A Complete Historical Geographical Architectural and Technological Survey* (Veloce, Dorchester)

Edmonds, J, 2004, *The History of Rotherwas Munitions Factory Hereford* (Logaston Press, Hereford)

Edwards, B, 'National Filling Factory No 5 Quedgeley' in *Gloucestershire Society for Industrial Archaeology Journal,* 1994, pp. 32-52

Fraser, P, 1983, 'The British "Shell Scandal" of 1915' in *The Canadian Journal of History*, Vol 18 Pt 1, (Univ. Toronto Press) pp. 69-86

Greenwich Council, 2007, 'Progress Estate Conservation Area Character Appraisal' (Pdf viewed at www.royalgreenwich.gov.uk (accessed 20/01/15)

Guillery, P, (ed) 2012, *Survey of London* Vol 48 Woolwich (English Heritage/Yale University Press, London)

Gurnmer, R, 1919, *How the Shells were Filled. The Story of Barnbow* (Hunter and Sons, Leeds) copy in TNA MUN5/155/1122.3/54

Haslam, J, 2005, *The Chilwell Story, VC Factory and Ordnance Depot* (Second Edition, Excelsior, Nottingham)

Johnson, A, 'Homes for war-workers' in *IHBC Journal*, No. 137, November 2014, pp. 25-27

Lloyd George, D, 1938, *War Memoirs of David Lloyd George* (Odhams, London)

Ministry Of Munitions, 1918, *Directory of Manufacturers in the Engineering and Allied Trades* (HMSO, London)

Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* Vol. VIII, Pt II, 'The National Factories', (HMSO, London)

Ministry of Munitions, nd. *A Short History of National Filling Factory No. 7 Hayes, Middlesex* (Harrison and Sons, Hayes), copy in TNA MUN5/154

Pam, D, 1998, *The Royal Small Arms Factory Enfield and its Workers*, (Private pub, Enfield)

Putnam, T, & Weinbren, D, 1992, *A Short History of the Royal Small Arms Factory Enfield* (Royal Ordnance Plc/Middlesex University, Middlesex)

RCHME, 1994, *The Royal Arsenal Woolwich, Historic Buildings Report* 2 Vols, (Royal Commission on the Historical Monuments of England, London)

RCHME, 1994, *The Royal Gunpowder Factory, Waltham Abbey, Essex and RCHME*

Survey 1993, 2 Vols, (Royal Commission on the Historical Monuments of England, London)

Saint, A, 1989, 'Spread The People: The LCC's Dispersal Policy 1889-1965', in Saint A (ed.) *Politics and People of London: London County Council 1889-1965* (Bloomsbury, London)

Simmonds, A, 2013, *Britain and World War One* (Routledge, Abingdon)

Stratton, M, and Trinder, B, 2000, *Twentieth Century Industrial Archaeology* (E and F N Spon, London)

Swenarton, M, 1981, *Homes Fit for Heroes, The Politics and Architecture of Early State Housing in Britain* (Heinemann, London)

Online Resources

http://1914-1918.invisionzone.com/forums/index.php?showtopic=120277 (accessed 04/11/2014)

http://canmore.rcahms.gov.uk/en/site/121301/details/eastriggs+65+pretoria+road/ (accessed 20/1/2015

http://discovery.nationalarchives.gov.uk/details/rd/82bf9e06-8dc8-4c68-93d7-ace1c2980a1e (accessed 27/11/2014)

http://en.wikipedia.org/wiki/Peter_Hooker (accessed 6/10/2014)

http://merseyside-at-war.org/memorabilia/munitions-factory-in-north-haymarket-liverpool/ (accessed 14/10/2014)

http://www.british-history.ac.uk/report.aspx?compid=42827 (accessed 27/11/2014)

http://www.burton-on-trent.org.uk/category/surviving/branston-depot/branston-pickle (accessed 2/12/2014)

http://www.cumberlandnews.co.uk/war-office-fought-for-control-of-carlisle-drill-hall-1.784415 (accessed 12/01/2015)

http://www.disused-stations.org.uk/c/chaul_end/ (accessed 12/01/2015)

http://www.ford.co.uk/experience-ford/Heritage/EvolutionOfMassProduction (accessed 24/02/2015)

http://www.gracesguide.co.uk/Serck_Radiators (accessed 06/10/2014)

http://www.gracesguide.co.uk/Thomas_Chatwin (accessed 6/10/2014)

http://www.iwm.org.uk/history/anna-airy (accessed 14/10/2014)

http://www.nationalarchives.gov.uk/pathways/firstworldwar/britain/p_munitions.htm (accessed 13/8/2014)

http://www.miac.org.uk/cadburyblackpole.html (accessed 29/9/2014)

http://www.serck.com/history.html (accessed 11/11/2014)

http://www.suttonbeauty.org.uk/suttonhistory/poisongas.html (accessed 27/11/2014)

http://www.sydenhams.co.uk/ (accessed 2/12/2014)

http://www.theatrestrust.org.uk/search?page=13&q=demolished&type=theatre (accessed 11/11/2014)

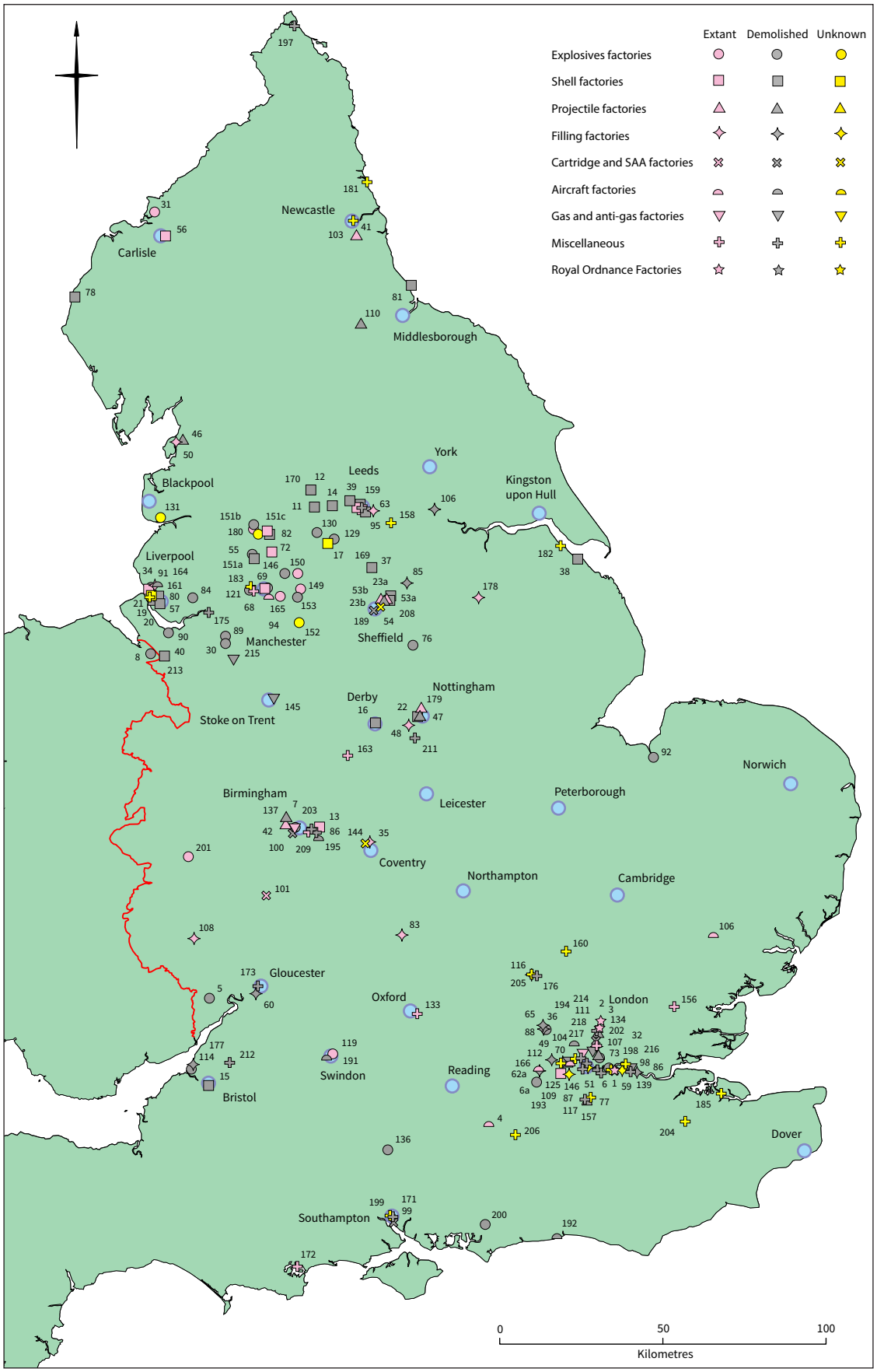
www.britainfromabove.org.uk/image/epw019264 (accessed 20/10/2014)

APPENDIX A LIST OF NATIONAL FACTORIES

Key to colour coding	
	Some buildings or other features survive on site
	Factory buildings known to be demolished
	Location of factory and survival of structures unknown
	Factories in Scotland, Wales and Ireland (excluded from study)

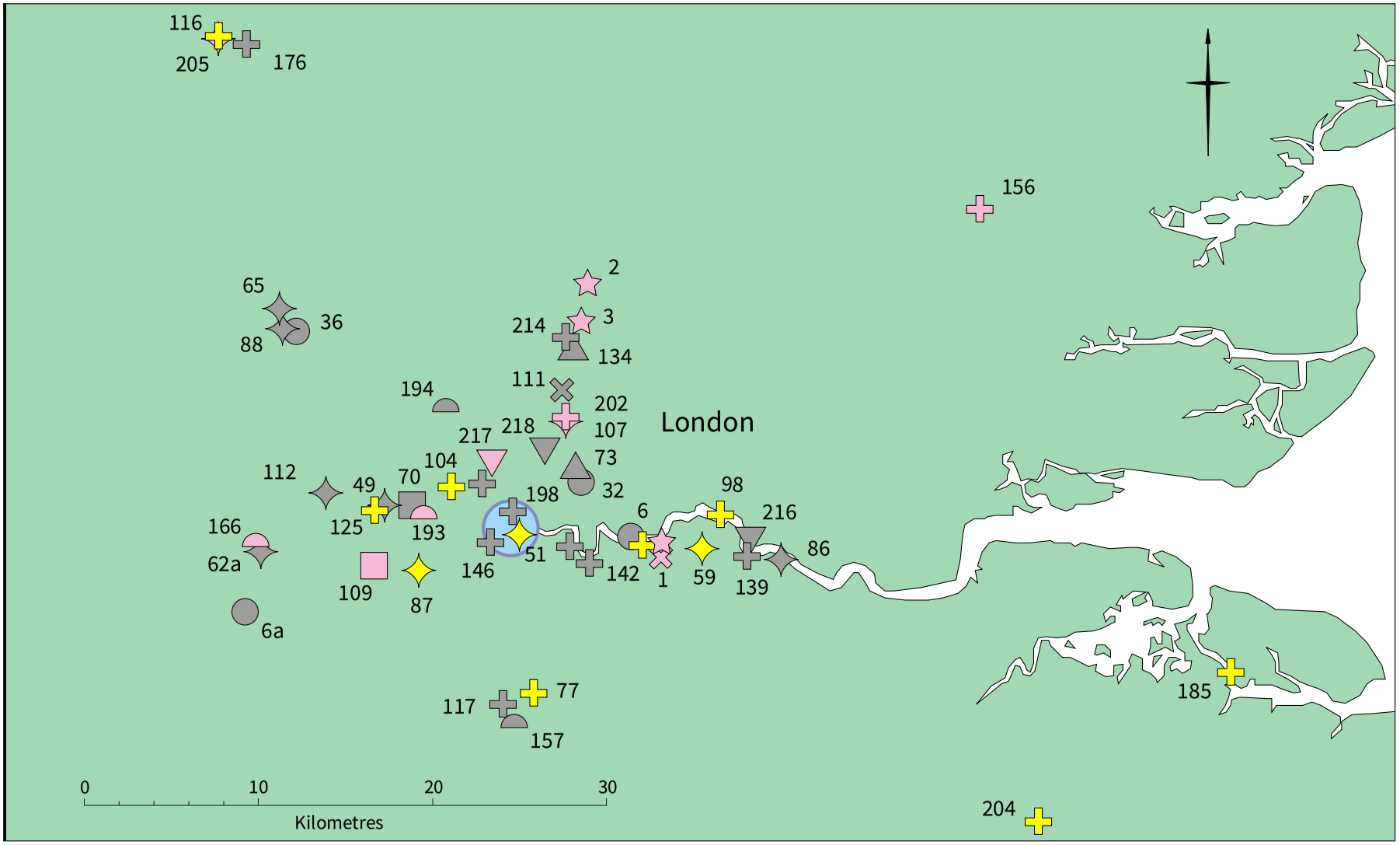
Where an entry has been created for each site in the National Record of the Historic Environment (NRHE) this is listed.

All factories were also numbered in the 'Chronological schedule' included as Appendix IV of the Ministry of Munitions official *History* This number is included in brackets after the site name in the following tables. This is also the identifier used on the maps.



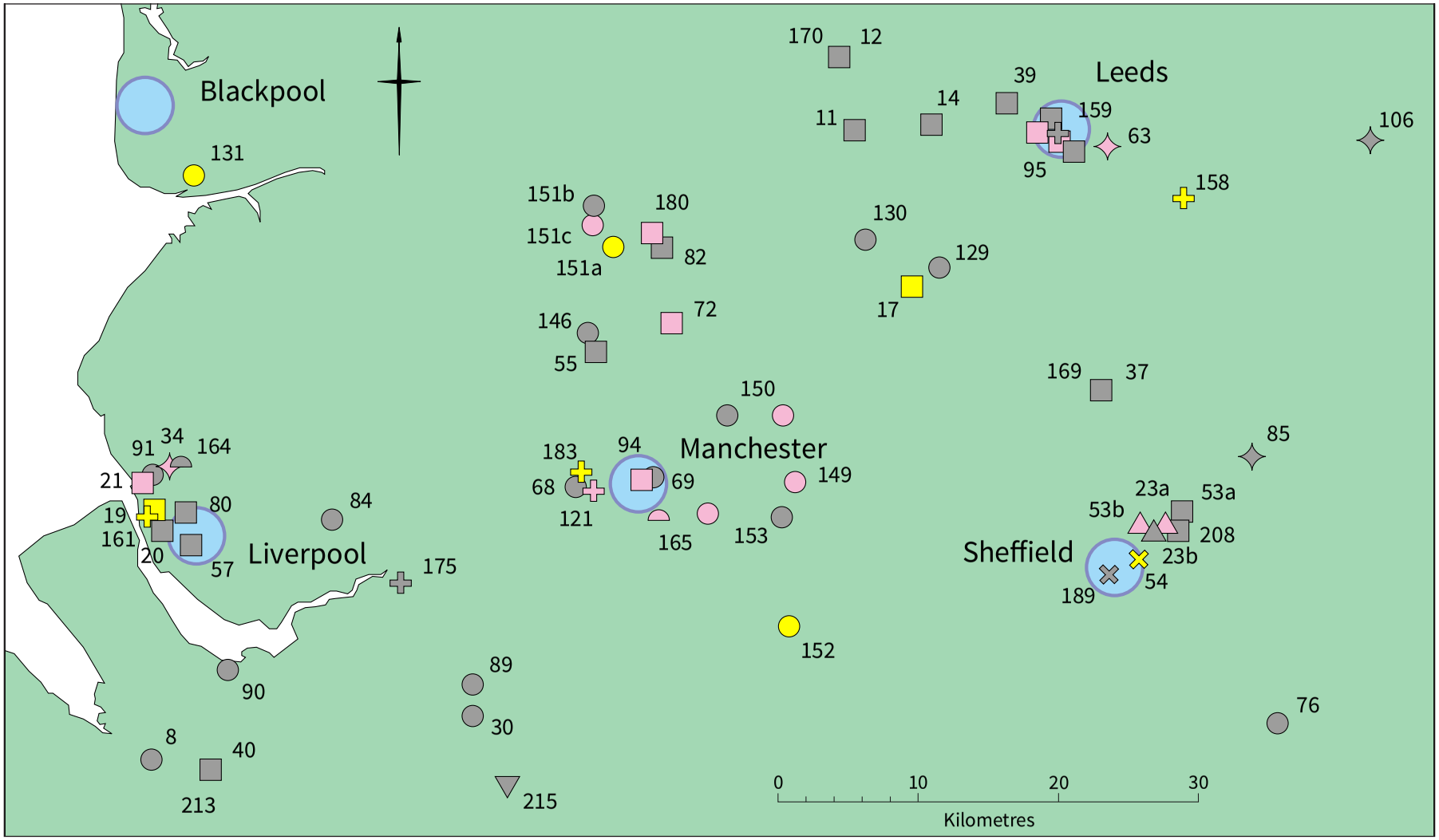
National Factories in England

© HISTORIC ENGLAND



Concentration of National Factories in the London area

© HISTORIC ENGLAND



Concentration of National Factories near Manchester, Sheffield, Leeds and Liverpool

© HISTORIC ENGLAND

Royal Ordnance Factories

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
911843 and 911656	Royal Ordnance Factories	**Woolwich (1)**	Royal Arsenal Beresford Street Woolwich London	Extant	TQ 43996 79200	Making and repairing guns, carriages, making filling and assembling shells and components making SAA	Established 1695. Pre-existing buildings used for WW1 production survive, and are listed, but no 1914-1918 built buildings are extant.
Not Allocated	Royal Small Arms Factory	**Enfield Lock (2)**	Enfield Island Village, Enfield	Extant	TQ 37258 98512	Rifles, machine guns and small arms	Established 1804. Pre-existing buildings used for WW1 production survive but no 1914-1918 built buildings are extant.
1010269	Royal Gunpowder Factory	**Waltham Abbey (3)**	Beaulieu Drive, Waltham Abbey	Extant	TQ 37674 01400	Cordite, Guncotton, Gunpowder, Tetryl, and fuse powder	Established 1787. 1914-1918 buildings survive in cordite factory on eastern flank, as well as earlier structures.

© HISTORIC ENGLAND

Explosives Factories

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Explosives							
1078413	HM Explosives Factory	**Avonmouth (114)**	Kings Weston Lane, Avonmouth	Demolished	ST 52205 79637	Picric acid, later mustard gas	Site appears on 1938 OS and is mapped by Bristol HER project. Buildings are now demolished.
1076644	HM Explosives Factory	**Bradley (129)**	Yorkshire	Demolished	SE 16905 19386	Picric acid	The new picric acid plant is described in OH as between the railway and the canal and separated from Holliday's existing Dalton works by a railway embankment. A chemical works is shown on the 1938 OS in a likely location NE of the Dalton works. This site has been entirely demolished.
1075228	HM Explosives Factory	**Ellesmere Port (90)**	Ellesmere Port , Cheshire	Demolished	SJ 41866 76871	Synthetic phenol	Site is described in OH as alongside the ship canal and on land rented from the Ship Canal Portland Cement Co. A chemical works appears on OS 1938 a short distance east of the cement works, now demolished. The site is occupied by industrial buildings. Two similar building footprints may reflect surviving structures.
1074633	HM Explosives Factory	**Gadbrook (30)**	Nr Northwich Cheshire	Demolished	SJ 68023 72169	Purifying crude TNT	Brunner Mond. This factory was located at Gadbrook in otherwise open country. There is a factory on the edge of Gadbrook on post war maps not present in 1911. Probable that this is the site. Now demolished.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1076589	HM Explosives Factory	**Greetland (130)**	Nr Halifax	Demolished	SE 09512 22145	Picric acid	Sharp & Mallet. Factory location is described in OH as on the River Calder, two miles from Halifax, near Greetland Station. Whole establishment was dismantled in 1919-20.
1087349	HM Explosives Factory	**Gretna (31)**	Nr Carlisle	Partially extant	NY 35491 66936	Cordite R D B	Explosive storage buildings survive at Smalmstown. Also housing on Scottish side of border.
1572532 1075949	HM Explosives Factory	**Hackney Wick (32)**	Wallis Road, London	Demolished	TQ 36973 84512	TNT	Several chemical works are shown on OS maps at end of White Post Lane. Other chemical and dyeworks are present but all have been demolished.
Not yet allocated	HM Explosives Factory	**Langwith (76)**	Near Mansfield, Derbyshire	Demolished	SK 52763 70890	Ammonium perchlorate	Plant was established adjacent to Langwith colliery on west side. Whole site now demolished, used as a coal tip, and now a country park.
1078019	HM Explosives Factory	**Litherland (91)**	Liverpool	Demolished	SJ 33854 97373	TNT	Site adjacent to Brotherton and Co. tar distillery on Hawthorne Road. Whole area has been demolished, now a superstore.
1078060 1078860	HM Explosives Factory	**Lytham (131)**	Lancashire	Demolished	AD 38186 28908	Picric acid	Mr Lance Blythe. Factory was built on land of Warton Hall Farm to NE of town, adjacent to railway. A short lived works with rail siding appears on the 1932 map. Now a caravan park.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1075148	HM Explosives Factory	**Oldbury (7)**	Worcestershire	Demolished	SO 99299 88799	TNT	Chance & Hunt; not exactly clear where these plants were erected but no suitable surviving buildings have been identified in the locations described in Official *History*.
1572393 1075848	HM Explosives Factory	**Rainham (6)**	Essex	Demolished	TQ 41429 80006	Purifying crude TNT	Coley & Wilbraham. 'Island Wharf' chemical works, Rainham is shown on historic OS Map. Buildings no longer extant.
1076774	HM Explosives Factory	**Sutton Oak (84)**	Reginald Road Sutton	Demolished	SJ 53141 92664	Synthetic Phenol, latterly chemical warfare agent	Factory was to the south of Reginald Road adjacent to the railway line. Plant remained in use as chemical warfare factory until the 1950s when it was completely demolished and decontaminated.
1075159	HM Explosives Factory	**Swindon (119)**	Stratton Works	Partially extant	SU 16515 86499	Ammonium nitrate	Works depicted on historic OS. Bungalow by entrance and one stores building shown on 1923 map survive in situ.
1076782	HM Explosives Factory	**Trafford Park (68)**	Manchester	Demolished		Refining toluol	Hardman & Holden. Several chemical works are depicted on historic mapping in Trafford Park, it is not clear which is this plant. All are now demolished.
1074628	HM Explosives Factory	**Victoria Works (89)**	Northwich	Demolished	SJ 67818 75070	Calcium nitrate tetrahydride	Salt Union. Northwich Victoria Works is shown on pre-war OS. It is now occupied by Northwich Victoria football ground.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1077977	HM Explosives Factory	**Watford (36)**	Balmoral Road	Demolished	TQ 11339 97629	Amonal, Amatol, Smoke powder (Experimental)	Buildings are visible on post-war mapping but likely that factory buildings were quickly replaced. North end of site adjacent to Balmoral Road may be Explosives Factory with TWFF to south.
Not yet allocated	HM Explosives Factory	**West Gorton (69)**	Chemical Works, Manchester	Demolished	SJ 87047 97122	Synthetic Phenol and TNT	Gorton Brook chemical works is marked on pre and post war OS. Now demolished.
1078832	HM Explosives Factory	**Colnbrook (106a)**	Middlesex	Demolished	TQ 03234 75876	Guncotton	Leased from Belgian government. Site is shown on Middlesex 1914 OS map marked 'explosives works'. Site is now industrial estate.
Wood Distillation & Acetone							
1572410 1077747	HM Explosives Factory	**Bideford (9)**	Devon	Unknown	SS 45635 25944	Acetate of Lime by wood distillation	MUN4/6187 (TNA) describes the factory as 'adjacent to L&SW Railway 1/2 mile S of Bideford station fronting River Torridge' This corresponds with a timber yard shown on both 1904 and 1932 OS maps. Now occupied by builders yard.
1572411 1075138	HM Explosives Factory	**Coleford (5)**	Speech House Road, Coleford, Gloucester	Demolished	SO 60898 11612	Acetate of Lime by wood distillation	Works marked on old OS. MUN4/6187 (TNA) describes site as two miles from Coleford on Monmouth Road, adjoining Speech House Road Station.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1075622	HM Explosives Factory	**Longparish (136)**	Nr Andover, Hampshire	Demolished	SU 41175 43190	Acetate of Lime by wood distillation	Sawmill and distillation plan established adjacent to Longparish station. Visible on 1938 map. Now occupied by small industrial estate. MUN4/6187 describes it as five miles east of Andover 300 yards from Longparish adjacent to Andover to Micheldever Road.
1075568	HM Explosives Factory	**Ludlow (201)**	Ludlow, Shropshire	Possibly extant	SO 50836 75602	Acetate of Lime by wood distillation	Plant appears on OS maps post-war, of which some buildings are still standing. This is probably the site. MUN4/6187 describes it as half a mile north of station. MUN4 6053 says 'just outside the town on a strip of land between the main road and the railway'.
1077731	HM Explosives Factory	**Mid Lavant (200)**	Nr Chichester	Demolished	SU 85356 09172	Acetate of Lime by wood distillation	Located in field no 88 on historic OS map. leased from West Lavant Farm. Now part of Eastmead Industrial Estate. No post-war mapping available. Aerial ropeway formerly connected site with woods to east. on Goodwood estate.
1075185	HM Explosives Factory	**King's Lynn (92)**	Norfolk	Demolished	TF 61507 20706	Acetone	Former oil cake factory near docks, marked on OS post war as a chemical factory. Now demolished.

© HISTORIC ENGLAND

National Cotton Waste Mills							
NRHE UID	**Historic classification**	**Title**	**Address/ Location**	**Condition**	**NGR**	**Output**	**Notes**
1084662 1076883	HM Cotton Waste Mill	**Bury (146)**	Calrow Mill	Demolished	SD 80102 12485	Cotton waste	Occupied former Calrow or Carlow? Mill now demolished, excavated in 1991.
1575535	HM Cotton Waste Mill	**Charlesworth (147)**	Lee Valley Mill	Demolished	SK 00473 92757	Cotton waste	Firm evidence that this was the site could not be identified
1076776	HM Cotton Waste Mill	**Greenfield (148)**	Yorkshire	Extant?	SE 00879 03651	Cotton waste	Green field mill was converted to a paper mill and continued until the mid-2000s, currently derelict, may include WW1 period features.
1364763 1076780	HM Cotton Waste Mill	**Hadfield (149)**	Waterside Mill	Extant?	SK 01953 96658	Cotton waste	Site is marked on wartime OS, some building footprints match so parts may be extant.
1586241 1076881	HM Cotton Waste Mill	**Oldham (150)**	Holts Mill	Demolished	SD 94845 03670	Cotton Waste	Holts Mill is marked on pre and post war OS. Buildings have been demolished but site remains undeveloped green space.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet allocated	HM Cotton Waste Mill	**Rawtenstall (151)**	Cloughfold Mills	Unknown		Cotton waste	Not possible to identify this mill. There are several in Clough Fold.
1575855 1078684			Constable Lee Mill	Extant	SD 80938 23791		Mill building is extant and Listed.
1586264 1078041			Holme Mills	Demolished	SD 80794 24327		Holme Mill is marked on OS, now demolished but site is wooded, millstream appears to pass under floor slab.
1075702	HM Cotton Waste Mill	**Whaley Bridge (152)**	Hall's Mill	Unknown		Cotton waste	Two mills are present in Whaley Bridge. Neither can be associated with Hall's.
1076877	HM Cotton Waste Mill	**Woodley (153)**	Arden Mill	Extant	SJ 92669 93371	Cotton waste	Mill is labelled on historic OS now derelict- decaying rapidly.
Scotland, Wales & Ireland							
	HM Explosives Factory	**Craigleith (102)**				TNT	Lothian Chemical Co.
	HM Explosives Factory	**Irvine (132)**				Nitrocellulose powder	Nobel's Explosives Co.
	HM Explosives Factory	**Pembrey (126)**	Carmarthen			TNT Tetryl, Propellants	Nobel's explosives Co.
	HM Explosives Factory	**Penrhyn Deudraeth(33)**	N. Wales			TNT	

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
	HM Explosives Factory	**Queen's Ferry with Sandycroft (8, 213)**	Chester (Welsh side of Dee)	Demolished	SJ 33865 67348	Guncotton, TNT and tetryl	Official *History* records that the site was a derelict engineering works. Such a site appears on OS and a chemical plant is depicted post-war. (Now demolished.) Housing at Mancot in Wales survives.
	HM Explosives Factory	**Dundee (10)**	Graham Street			Acetate of Lime by wood distillation	

© HISTORIC ENGLAND

© HISTORIC ENGLAND

Shell Factories

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572640	National Shell Factory	**Barnsley No. 1 (37)**	Dominion Works, Johnson Street	Demolished	SE 33550 06560	4.5in shell	The exact location of the factory is uncertain. The 1931 OS Map shows 'Empire Mills' and a railway foundry next to Johnson Street. One of these works may have used the pre-existing factory buildings or, alternatively, the factory may have been demolished.
946734	National Shell Factory	**Barnsley No. 2 (169)**	Hope Works, Sackville Street	Demolished	SE 34095 06428	4.5in shell	
1572642	National Shell Factory	**Birmingham (13)**	Midland Works, Washwood Heath, Birmingham	Part extant?	SP 10441 89105	Making and commpleting 18pdr and 4.5in shell	Midland Works survives almost complete as ALSTOM railway works on Common Lane.
944483	National Shell Factory	**Bradford (14)**	Valley Road, Bradford	Demolished	SE 16200 34300	4.5in shell fuses, gaines etc., completing 4.5in shell	
1572644	National Shell Factory	**Bristol (15)**	Victoria Road, Bristol	Demolished	ST 60110 72140	completing and rectifying 18pdr shell	The exact location of the factory is uncertain. It is not marked on the 1918 OS map. An iron foundry is marked at the extreme southern end of Victoria Road, Official *History* indicates the site was 'Castle Ironworks (J Priest and Son) Victoria Road, St Philips Marsh'. This foundry conforms to that address. No buildings survive.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1574442	National Shell Factory	**Bury (55)**	Corporation Tramway Depot, Rochdale Road, Bury	Demolished	SD 80920 10760	18pdr and 4.5in shell, rectifying shell	
Not yet allocated	National Shell Factory	**Derby (16)**	Peel Foundry, Darwen Terrace	Demolished	SK 35921 36380	4.5in and 4.7in shell; 60pdr and 6in shell heads; aero engine cylinders	Russell & sons Ltd. Peel Foundry is depicted and labelled on the 1914 OS map.
1572916	National Shell Factory	**East Cumberland (Carlisle) (56)**	Drill Hall, Strand Road, Carlisle	Partially extant	NY 40397 56085	18pdr shell, rectifying proof shot	The East Cumberland National Shell Factory was established at a War Office Rifle Drill Hall on Strand Road, Carlisle. Drill hall is partially demolished, other buildings survive.
1574487	National Shell Factory	**Grimsby (38)**	Mr A L Black's Premises, Victoria Street, Grimsby	Demolished	TA 27149 10125	4.5in and 6in shell	The exact location of this factory could not be determined using historic OS maps. Evidence suggests that it was in a former herring curing factory adjacent to the Artillery Barracks. No pre-1945 buildings survive in this area.
Not yet allocated	National Shell Factory	**Hartlepool (81)**	Central Marine Engine Works, West Hartlepool	Demolished	NZ 51723 34008	8in shell	Central Marine Engine Works is depicted on 1919 OS map.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572949	National Shell Factory	**Huddersfield (17)**	Fitzwilliam Street, Huddersfield	Part extant	SE 14399 17155	18pdr shell and shell heads	Not possible to identify particular building on Fitzwilliam Street associated with the factory.
1572944	National Shell Factory	**Keighley No. 1 (12)**	Engineering Works, Dalton Lane, Keighley	Demolished	SE06540 41468	18pdr, 3.7in and 6pdr AA shell	Factory owned by Prince Smith & Sons, listed at Burlington Sheds, opposite west end of Dalton Lane, depicted on 1919 OS. Site is demolished and now an Asda.
1572946	National Shell Factory	**Keighley No. 2 (170)**	Engineering Works, Dalton Lane, Keighley	Demolished	SE 06819 41497	18pdr shell casings	Factory was located at premises of Hall & Stells, listed on internet as at Park Works. OS shows two sites for Park Works, N and S of Dalton Lane, a foundry and an engineering shop, both now demolished.
1572952	National Shell Factory National Projectile Factory National Ordnance Factory	**Leeds (Armley Road) (11)**	Premises recently in occupation of the Leeds Munitions Company, Leeds	Demolished	SE 28083 33837	4.5in and 6in shell, repair and inspection of guns	The factory was placed in new railway carriage shops built by the Leeds Forge Co. on Armley Road. The Leeds forge site is visible on the 1908 OS and is shown extended towards the railway on the 1921 map. It is likely that this is the location of the NSF. All these buildings are now demolished.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
956110	National Shell Factory National Projectile Factory National Ordnance Factory	**Leeds (Hunslet) (95)**	Premises at Hunslet recently occupied by Messrs. Tannett-Walker, Leeds	Demolished	SE 31224 32163	9.2in and 15in shell: making and repairing guns	Located in derelict Goodman Street Works, marked on 1921 OS. Now demolished
1572954	National Shell Factory National Projectile Factory National Ordnance Factory	**Leeds (Newlay) (39)**	Premises Adjoining those of Schoen Wheel Company, Newlay, Leeds	Demolished	SE 24465 36675	9.2in and 15in shell	Site of wheel factory and adjoining buildings are shown on 1921 OS, but appear to have been demolished prior to 1930s map. Site is currently wooded. Some earthworks/floor slabs may survive.
1572469	National Fuse Factory	**Leeds (96)**	Armley Road (NOF No. 4)	Possibly extant	SE 28519 33456	Shell components	Armley road fuse factory (Known as NOF No. 4) Was in J Hattersley & Sons works adjacent to Leeds forge. This was a former spindle factory adjacent to Brandon Street, marked on historic OS. The buildings occupying this site are possibly of early C20 date.
1572471			Wellington Street (NOF No. 5)	Demolished	SE 28976 33562	Shell components	Internet sources suggest this was at the Fairburn Lawson Coombe Barbour works on the corner of Wellington Street and Wellington Bridge Street. This building was recently demolished to make way for TGI Fridays and a hotel.

NHRE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572472			Sweet Street (NOF No. 6)	Possibly extant	SE 29478 32617	Shell components	Internet sources suggest that this site was acquired from Marshall Mills, if so then it may be part of the Temple Mills complex, possibly the southern Linen Factory extending onto West Sweet Street on historic OS. This building and the remainder of Temple Mill are extant and Listed. Alternatively the factory may have been located in works further to the east adjacent to the school, now demolished.
Not yet allocated	National Shell Factory	**Liverpool (Haymarket) (20)**	North Haymarket, Liverpool	Demolished	SJ 35028 91643	18pdr 4.5in & 6in Shell	Factory was established in the former agricultural market at the North Haymarket, Great Homer Street. The site was re-instated as a market post war but the whole district is now extensively redeveloped.
1078897?	National Shell Factory	**Liverpool (Cunard) (19)**	Cunard Co. Rimrose Road	Part extant?	SJ 33220 96140	8in 6in & 4.5in shell	Works still stands on Rimrose Road.
1572966	National Shell Factory	**Liverpool (Edge Lane) (57)**	Edge Lane, Liverpool	Demolished		4.5in and 6in shell forgings, 4.5in cartridge cases	

© HISTORIC ENGLAND

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572968	National Shell Factory	**Liverpool (Lambeth Road) (21)**	Lambeth Road Tramway Depot, Liverpool	Demolished		18pdr shell, completing and rectifying 18pdr, 15pdr 2.75in 4.5in and 60pdr	
Not yet allocated	National Shell Factory	**Liverpool (Bootle) (80)**	Clyde Street, Bootle	Extant?	SJ 34055 93842	Gauges	Buildings are present on Clyde Street which show continuity on OS maps, however precise premises of Technical Engineering Co. could not be established.
1574473	National Shell Factory	**Liverpool (Chester) (40)**	Chester Tramway Depot	Demolished	SJ 39920 66350	18pdr and 2.75in shell	Actually at the electrical generating station on New Crane Road. Now demolished.
1572983	National Shell Factory	**Manchester (94)**	Tramway Depot, Hyde Road, Manchester	Extant	SJ 85865 97009	4.5in shell	This factory was established at the Manchester Corporation Tramways Hyde Road Depot in 1916. Historic OS maps indicate that the Tram Depot was constructed sometime between 1893 and 1908 and is still largely extant.
1575744	National Shell Factory, National Projectile Factory	**Metropolitan (Ailsa Craig) (109)**	Strand on the Green Chiswick	Extant	TQ 19492 77743	4.5in shell	Formerly the motor works of the Alisa Craig Motor Co. Factory building still extant.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1573107	National Shell Factory National Projectile Factory	**Metropolitan (College Park) (70)**	Willesden NW	Unknown	TQ 22734 82804	Shell components	Former engine packing works of Messrs Klinger (interned as enemy alien) some works shown in college park area survive and are of a suitable date, but not known which is Klinger works. Pegasus works, now demolished, is the only engineering works in College Park proper.
Not yet allocated	National Shell Factory	**Nottingham (22)**	Springclose Works, Commercial Street, Old Lenton Nottingham	Demolished	SK 54819 38837	13pdr, 18pdr, 2.75in shell, completing 18pdr	Spring Close Works, Commercial Street is depicted as a 'Lace Factory' (as per Official *History*) on historic OS, however the whole area is demolished and now occupied by Queens Medical Centre.
1574492	National Shell Factory	**Rawtenstall and Bacup No.1 (82)**	(part of) Irwell Mill, Bacup	Extant	SD 86902 22740	4.5in shell	Cartographic evidence indicates that the current building on the site resembles the footprint of the southern part of the original. It may therefore still be (part) extant.
1574493	National Shell Factory	**Rawtenstall and Bacup No.2 (180)**	Height Barn Mill	Demolished	SD 87428 21726	Rectifying 18pdr, 4.5in shell and 6in shell forgings	Mill is shown on historic OS, now demolished.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572986	National Shell Factory	**Rochdale (72)**	Municipal Tramway Works, Mellor Street, Rochdale	Extant	SD 88661 13630	6in shell	Tramway shed is still extant on Mellor Road.
1574519 1574521	National Shell Factory	**Rotherham (23)**	Brinsworth Iron Works, and Rother Iron Works Rotherham	Demolished	SK 41970 91797 and SK 42171 92459	4.5in shell	Brinsworth site has been demolished, but part of Ickles (Rother Iron Works site), appears to be standing surrounded by other buildings.
1572999	National Shell Factory	**West Cumberland (Workington) (78)**	Hawkshead Foundry, Stanley Street, Workington	Demolished	NX 99425 29003	18pdr shell, base plates	Hawkshead Foundry is show on historic OS but now demolished.
Scotland Wales & Ireland							
	National Shell Factory	**Aberdeen (135)**	Spring Gardens Iron Works			Completing 6in shell	
	National Shell Factory	**Dundee (24)**	51-63 Mains Road			18pdr, and 2.75in shell, forgings, burster containers	
	National Shell Factory	**North Wales (Wrexham) (28)**	Corporation Electric Works			Making and completing 18pdr and 13pdr shells	

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
	National Shell Factory	**North Wales (Portmadoc) (75)**	Boston Lodge Works			18pdr and 13pdr shells	
	National Shell Factory	**North Wales (Caernavon) (71)**	Vulcan Factory			18pdr and 13pdr shells	
	National Shell Factory	**South Wales (Uskside) (29)**	Uskside, Newport, Mon.			18pdr, 4.5in, and 60pdr shell, gun carriage forgings etc.	
	National Shell Factory	**South Wales (Ebbw Vale) (25)**	Ebbw Vale, South Wales			18pdr and 60pdr shell	
	National Shell Factory	**South Wales (Newport) (74)**	Maes Glas and Tyne Engine Works			60pdr shell 4.5in and 9.2in nose bushes	Great Western Railway Works, Maes Glas, Newport.
	National Shell Factory	**South wales (Cardiff) (26)**	Ferry Road, Grange-Town, Cardiff			18pdr shell, 60pdr shell heads, 6in proof shot	
	National Shell Factory	**South Wales (Swansea) (27)**	Messrs Baldwin's Ltd, Landore, nr Swansea			18pdr and 4.5in shell	
	National Shell Factory	**South Wales (Llanelly) (58)**	Burry Extension Works			6in shell	

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
	National Shell Factory	**South Wales (Llanelly) (115)**				Rectifying 18pdr and 6in shell	
	National Shell Factory	**Dublin (18)**	Parkgate Street			18pdr shell	
	National Shell Factory	**Dublin (93)**	Parkgate Street			9.2in shell	
	National Fuse Factory	**Dublin (105)**	Parkgate Street			Fuses, aeroplane bolts	
	National Shell Factory	**Cork (97)**	North Main Street			4.5in shell	
	National Shell Factory	**Galway (120)**				18pdr shell	

© HISTORIC ENGLAND

Projectile Factories

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1575582	National Projectile Factory	**Birtley (41)**	Birtley, Co. Durham	Part extant	NZ 26697 56098	4in, 4.5in, 60pdr, 6in, 8in, shell, proof shot	The factory is not marked on OS maps, but a contemporary site plan in TNA and photos match the existing buildings on the site. The street plan of the associated 'Elizabethville' workers housing survives and two buildings are extant.
1574331	National Projectile Factory	**Darlington (110)**	N.E. Railway Co. Works	Demolished	NZ 28945 16012	18pdr and 6in shell, naval practice shot, repairing primers	NE Railway Co. Works marked on historic OS now demolished.
1574333	National Projectile Factory	**Dudley (42)**	Waddam's Pool	Extant	SO 94828 89890	18pdr, 60pdr, and 6in shell gun repair aero engine work	A Harper, Sons and Bean Ltd. Post-war sale catalogue at Dudley Archives. Factory building is largely extant.
1574334	National Projectile Factory	**Hackney Marshes (73)**	London NE	Demolished	TQ 36529 85179	6in shell and proof shot	Dick, Kerr & Co. Located on Mabley Green playing fields, now demolished however possible cropmarks visible on air photos.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1574435	National Projectile Factory	**Lancaster (46)**		Demolished	SD 48479 63501	60pdr,6in, 8in, and 9.2in shell gun repair and trench warfare work	Vickers, site south of point where canal crosses River Lune, now demolished and re-developed.
1575580	National Projectile Factory National Ordnance Factory	**Nottingham (47)**	King's Meadow Road	Demolished	SK 56354 38711	6in and 9.2in shell, making and repairing 18pdr guns	Cammell Laird & Co. now demolished and re-developed.
1574441	National Projectile Factory	**Sheffield (53)**	Tinsley Nr Sheffield and Templeborough Nr Rotherham	Extant	SK 39020 90467 and SK 40386 91305	shell forgings, 4.5in and 60pdr shell	T Firth & Sons. Buildings at Tinsley site have been demolished but forge at Templeborough partially survives.
1574223	National Projectile Factory National Ordnance Factory	**Sheffield (Hadfield) (54)**	East Heccla Works	Demolished	SK 39412 91007	9.2in shell 60pdr guns and gun repairs	Hadfield Ltd. Site now occupied by Meadowhall shopping centre.
1574436	National Projectile Factory National Ordnance Factory	**Ponders End (134)**		Demolished	TQ 36217 95361	6in 8in and 12in shell, 6pdr guns for (tanks) repairing guns	Plant taken over in October 1918, now demolished.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572889	National Ordnance Factory	**New Basford (179)**	Nottingham	Extant	SK 55979 42130	1 1/2 pdr gun	Former lace factory shown on historic OS is still extant.
1572461	National Component Factory	**Tipton (137)**		Demolished	SO 94918 92625	Gun ammunition components	A Harper, Sons and Bean Ltd. Work probably carried out within bounds of later Bean engineering works on Hurst Lane, all now demolished.
Scotland Wales & Ireland							
	National Projectile Factory	**Cathcart, Glasgow (52)**	Holm Foundry			8in shell, aeronautical work	Messrs J G Weir
	National Projectile Factory	**Glasgow (Mossend) (43)**	Mossend, Lanarkshire			Shell forgings	Beardmore Ltd
	National Projectile Factory	**Glasgow (Cardonald) (45)**	Cardonald, Renfrewshire			18pdr 6in and 8in shell, gun repair	Beardmore Ltd
	National Projectile Factory	**Glasgow (Mile End) (44)**	Grant's Mill, Mile End			18pdr 60pdr and 6in shell	Beardmore Ltd
	National Projectile Factory	**Renfrew (79)**	Aisne Factory			60pdr shell	Ypres & Aisne Co., Babcock & Wilcox
	National Projectile Factory	**Renfrew (67)**	Ypres Factory			9.2in and 12in forgings and shell	Ypres & Aisne Co., Babcock & Wilcox

© HISTORIC ENGLAND

Filling Factories

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1075961	National Filling Factory	**Abbey Wood No. 11 (59)**	London SE	Unknown		Filling and assembling shell components	Kings Norton Metal Co. No site located.
1077570	National Filling Factory	**Banbury No. 9 (83)**		Extant as earthworks	SP 47714 40223	Filling shell (6pdr to 9.2in) H.2 Mines	Site partially scheduled. Layout depicted on Plan in TNA and on historic mapping.
1085832	National Filling Factory	**Chilwell No. 6 (48)**	Long Eaton, Notts	Extant	SK 50703 35004	Filling shell (4.5in to 15in)	Filled shell store and other buildings extant on site now Ordnance depot.
Not yet allocated	National Filling Factory	**Coventry No. 10 or 21 (35)**	Foleshill, Whitmore Park	Partly extant	SP 33300 82211	Filling fuses, gaines and other components	White & Poppe Holbrook Lane Coventry. Former W & P works and the Dunlop factory shown on 1936 map, possibly some of this is former munitions works. Mostly demolished, parts of No 80 Fuse Factory on north-west side survive.
1077819	National Filling Factory	**Gainsborough No. 22 (178)**		Possibly some parts extant	SK 82488 93036	Filling mine sinkers	1948 map shows redundant sidings at NGR, also Google Earth shows possible bunded structures and irregular tree growth.
1078448	National Filling Factory	**Gloucester No. (60)5**	Quedgeley	Demolished	SO 81761 13418	Filling 18pdr, 4.5in and 60pdr shells, cartridges and components	Demolished 1924-26. Layout visible on post-war historic map.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1572418 1075846	National Filling Factory	**Hayes No. 7 (62)**	Middlesex	Demolished	TQ 09961 78921 and TQ 10732 86421	Filling shell (18pdr to 12in) cartridges components	Layout plan in TNA in published history of site. Note also magazine site at Northolt.
1083252	National Filling Factory	**Hereford No. 14 (108)**	Rotherwas, Hereford	Extant	SO 52850 38551	Filling shell (18pdr to 9.2in) charging gas shell	Site rebuilt in 1930s but some 1915-1918 buildings survive.
1386780 1067543	National Filling Factory	**Leeds No.1 (63)**	Barnbow	Extant EW	SE 34663 31993	Filling shell (18pdr to 6in) cartridges components	Survives as earthworks, currently under consideration for scheduling.
1077538 1077551	National Filling Factory	**Liverpool No. 2 (34)**	Aintree	Extant CM	SJ 35810 98391	Filling shell up to 8in, filling and assembling components	Buildings demolished, rail lines appear as crop-marks on Bootle golf course. Second NRHE number refers to extension of factory for amatol in 1916.
1572474	National Filling Factory (Fuse)	**Luton (116)**	Chaul End, Bedfordshire	Demolished	TL 06492 22509	Filling and converting fuses	Former workers rail station location at Chaul End Crossing. Factory was to the north-east, to the east of Chaul End Lane. (Plans on file).
Not yet allocated	National Filling Factory	**Morecambe No.13 (50)**	White Lund	One bldg extant?	SD 44946 62975	Filling 60pdr, 6in, 8in, 9.2in, and 12in shell	Vickers. Extent apparent on historic OS map, now a modern Industrial estate, one building on north edge may be standing (electic power plant).

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1075963	National Filling Factory	**Perivale No.3 (49)**	Willesden Lane London NW	Demolished	TQ 20616 82595	Filling shell components, experimental work	Site redeveloped in 1930s after Factory buildings became derelict.
1075970	National Filling Factory	**Southwark No. 8 (51)**	Sumner Street London SE	Unknown		Filling shell components, inspecting protective clothing	Possible location north of Sumner St shows large building on 1916 map, however vinegar factory at east end of street is also a possibility.

© HISTORIC ENGLAND

© HISTORIC ENGLAND

Trench Warfare							
NRHE UID	**Historic classification**	**Title**	**Address/ Location**	**Condition**	**NGR**	**Output**	**Notes**
1077688	Trench Warfare Filling Factory	**Denaby (85)**	Rotherham	Demolished	SK 49488 99350	Filling 3in stokes bombs, dis-assembling 3.7in bombs	British Westfalite Co. New filling factory built adjacent to existing explosives factory, extent of both shown on 1958 OS map prior to closure of factory in 1960s.
1075956	Trench Warfare Filling Factory	**Erith (86)**	Crayfordness, Slades Green	Demolished	TQ 53793 77873	Filling 2in and 6in trench mortar bombs	Built adjacent to Thames Ammunition Works. Extent of works pre-1914 shown on historic mapping, post-1918 expansion shows to south. Now occupied by industrial estate, no extant structures.
107593 1075978	Trench Warfare Filling Factory	**Fulham (No. 27?) (87)**	Stevenage Road	Unknown		Filling grenades, Stokes bombs and components, pyrotechnic work	Stevenage Lane is adjacent to Fulham football ground. No factory location info uncovered.
1077998	Trench Warfare Filling Factory	**Watford No.1 (65)**	Balmoral Road	Demolished	TQ 11339 97629	Filling and assembling trench warfare bombs, filling chemical shell exploders	Buildings visible on post-war mapping but likely that factory buildings were quickly replaced. North end of site adjacent to Balmoral Road may be explosives factory with TWFF to south.
1077982	Trench Warfare Filling Factory	**Watford No.2 (88)**	Bushey Mill Lane	Demolished	TQ 11681 98963	Filling bombs grenades etc, filling and assembling aerial bombs and trench mortar fuses, assembling chemical shell	Buildings visible on post-war mapping but likely that factory buildings were quickly replaced.

© HISTORIC ENGLAND

Chemical Shell							
NRHE UID	**Historic classification**	**Title**	**Address/ Location**	**Condition**	**NGR**	**Output**	**Notes**
1078472	National Filling Factory (Chemical)	**Chittening (177)**	Avonmouth, Bristol	Demolished	ST 53008 81670	Charging and assembling 6in chemical shell	Historic site plan available on Bristol HER. No original buildings apparent in modern Industrial Estate.
1075844	Chemical Shell Assembling Station	**Greenford (112)**	Middlesex	Demolished	TQ 15699 83802	Assembling lethal shell	Historic site plan available. All buildings demolished.
1575523 1075974	Trench Warfare Filling Factory (Chemical)	**Walthamstow (107)**	Black Horse Lane, London	Possibly extant		Charging lachrymatory grenades and shell, filling lethal shells	Several extant factory buildings in vicinity of Baird and Tatlock factory, not clear if any/which is NFF.
1572639	Trench Warfare Filling Factory	**Selby (106)**	Barlby Road	Demolished 2012	SE 62488 32822	Hydrogen and hydrogenated oils; charging chemical shell	On the 1908 OS map (1:2500) 'Ouse Chemical Works' are shown. OH says it was Ardol's factory which is Olympia Mills, extant until 2012 then demolished.
Scotland Wales & Ireland							
	National Filling Factory	**Cardonald No.12 (64)**	Govan, Glasgow			Filling minor shell components	Nobel's Explosives Ltd
	National Filling Factory	**Georgetown No.4 (61)**	Paisley			Filling shell (13pdr to 12in) cartridges, components, trench mortar bombs	
	National Filling Factory	**Pembrey No.18 (127)**	Burry Port Carmarthen			Filling 4.5in, 6in, 8in, shell. breaking down shell	

© HISTORIC ENGLAND

Cartridges and Small Arms Ammunition

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet allocated	Government Cartridge Factory	**No. 1 Blackheath (100)**	Staffs	Demolished	SO 98237 86523	SAA	Birmingham Metal and Munitions Co. Purpose built factory subsequently sold as an electrical works, marked on post-war OS as such, demolished in 1990s, floor slab is visible on aerial photos.
Not yet allocated	Government Cartridge Factory	**No. 2 Woolwich Arsenal (1)**	Woolwich	Demolished	circa TQ43637874		***See Woolwich.***
1574528	Government Cartridge Factory	**No. 3 Blackpole (101)**	Blackpole, Worcestershire	Extant	SO 86622 57775	SAA	King's Norton Metal Co. Factory was taken over by Cadbury's in 1919, main part largely extant.
1576272	Government Cartridge Factory	**No. 4 Edmonton (111)**	Angel Road	Demolished	TQ 35308 92180	SAA, aero engine repair	Eley Bros. New factory was built adjacent to existing plant on Angel Road site, most of the buildings on this site are now demolished and it is occupied by 'Eley's Estate' modern industrial units.
Not yet allocated	National Small Arms Ammunition Factory	**Coundon (144)**	Coventry	Unknown		Special SAA	Very small factory only 76 employees. No trace of location identified.
Not yet allocated	Government Rolling Mills	**Southampton (99)**	Woolston	Demolished	SU 43878 10128	Brass and cupro-nickel strips and cups	Factory is shown on post-war OS in Weston Park. Site now completely demolished and replaced by housing.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet Allocated	Manufacturing warehouse	**Sheffield (189)**	50 Porter Street	Demolished	SK 35160 86711	Cupro-nickel strip, brass discs	Warehouses are marked on Porter St on the 1923 OS, however the street no longer exists and the whole area has been redeveloped.
1574494	Casting Shop	**Sheffield (208)**	Bacon Lane	Extant?	SK 37408 88176	Bullets	Two possible sites exist for this works: Worthing Works, and Park House Works, either side of Bacon Lane, only Worthing works is extant.
Scotland Wales & Ireland							
	National Cartridge Case Factory	**Waterford (118)**				Cartridge cases	

© HISTORIC ENGLAND

Aircraft Production

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1381516	Royal Aircraft Establishment	**Farnborough (4)**	Farnborough Hampshire	Partially extant	SU 86737 54543	Aircraft and aircraft materials (Experimental)	Established 1905. Site continued in MoD hands until 1990s. Several pre-war listed buildings survive on the site.
1574595	National Aircraft Factory	**Aintree (164)**	Liverpool	Demolished	SJ 37058 98687	Aeroplanes	It is probable that this was the large works depicted on post-war OS to the north-west of the racecourse. This is entirely demolished and now occupied by Racecourse retail park.
1574577	National Aircraft Factory	**Heaton Chapel (165)**	Manchester	Partially extant	SJ 87448 92964	Aeroplanes	Former Crossley Works (later Fairey aircraft) is shown on historic OS and parts appear to be still extant.
1393200	National Aircraft Factory	**Croydon (157)**	Waddon	Demolished	TQ 31007 64044	Aeroplanes and CC interrupter gears	Holland, Hannen & Cubitt. Built adjacent to existing aerodrome buildings, all now demolished.
1220415	Aero-engine Factory	**Ladbroke Grove (193)**	Barlby Road	Partially extant	TQ 23577 81989	Repairing aero-engines	Talbot Car Works turned over to aircraft work. Main factory buildings have been demolished but office building survives and is listed at Gr II.
1574548	Aero-engine Factory	**Hayes (166)**	Blyth Road	Extant	TQ 09418 79498	Aero-engine parts	This factory was established in the former Goss printing works on Blyth Road, Hayes. This factory is marked on the 1914 OS and appears to be still extant.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1575548	National Balloon Factory	**Finchley (194)**	Church End	Demolished	TQ 25469 90863	Balloons	This factory was initially established in a former 'Picture Palace' on Ballards Lane. This was sold post war to become a boot polish factory. The latter is depicted on the 1936 map. All now demolished.
Not yet allocated	National Radiator Factory	**Greet (195)**	Birmingham	Demolished	SP 09857 83949	Radiators for aeroplanes	Motor Radiator Manufacturing Co. This factory was located on Warwick Road in Greet. A radiator factory is shown on the 1938 map and this corresponds with a smaller un-named works shown in 1916. Whole area now demolished and redeveloped.
Not yet allocated	National Radiator Factory	**Sudbury (196)**	Suffolk	Partially Extant	TL 88454 40221	Radiators for aeroplanes	Motor Radiator Manufacturing Co. Later became Serck Radiator Co. Located on Radiator Road, depicted on 1923 OS map and marked as Radiator Works. Company later moved 1935 to Meadow Lane, Sudbury. One building survives adjacent to south side of Radiator Road.
Not yet allocated	National Timber Drying Kiln	**Lancing (192)**	LB & SCR Co. works	Demolished	TQ 17723 03786	Drying timber for aircraft	Timber kiln was established at LB & SCR carriage works (later SR carriage works). The two main carriage shops (1912 and 1930s) appear to survive within an industrial estate, but the kiln would appear to be demolished.
Not yet allocated	National Timber Drying Kiln	**Swindon (191)**	GWR Co. works	Demolished	SU 13310 84473	Drying timber for aircraft	Timber kilns are marked on the 1930s guides to site as part of Carriage shops to south of the main line, but whether this location is same as 1918 is not known. Info from 'Swindon in the Great War' via Twitter suggests location at this grid ref. Sheds visible on 1923 map.

© HISTORIC ENGLAND

Chemical and Anti-Gas

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Anti-Gas Factory							
Not yet allocated	Anti-Gas Factory	**Stamford Hill (124)**	LCC Stores Depot	Demolished	TQ 33909 87498	Granules	This factory was established in The LCC depot Stamford Hill. An LCC Depot is shown on the 1935 OS on Portland Avenue. The same un-named structure is present on the 1916 map. Whole area now demolished.
1574523	Anti-Gas Factory	**Holloway (217)**	Batavia Mills	Extant	TQ 29591 86804	Respirators	Batavia Mills on Elthorne Road, still extant.
1574525	Anti-Gas Factory	**Holloway (218)**	Holloway Mills	Extant	TQ 29618 86898	Respirators	Holloway Mills on Elthorne Road still extant.
Chemical Warfare Factory							
Not yet allocated	Chemical Warfare Factory	**Langley (203)**		Unknown		Chemicals	There is a large chemical works at Langley (Birmingham) part of the former Chance & Hunt Works but it is not known if or where this relates to the NCWF.
Not yet allocated	Chemical Warfare Factory	**Middlewich (215)**		Demolished?	SJ 71279 64851	Making and charging poison gas	Former works of Electro-Bleach & By-Products Ltd, previously Electrolytic Alkali Co. has named works on 1909 OS on Cledford Lane, Middlewich. Site appears now to be occupied by later pottery.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet allocated	Chemical Warfare Factory	**Rainham (216)**		Demolished?	TQ 51407 80604	Chemicals	There are internet references to poison gas manufacture at Rainham Ferry, at the former soap works. The south Metropolitan Gas Co. site could not be traced. If this is the correct location no buildings survive.
Not yet allocated	Cylinder depot	**Bucknall (145)**	Handley Staffs	Demolished	SJ 89749 47502	Evacuating and refilling cylinders with chemicals	Depot established at Bucknall Sawmills Co. Site marked on 1924 OS map, no buildings survive.

© HISTORIC ENGLAND

Miscellaneous

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
National Gauge Factories							
1573411	National Gauge Factory	**Birmingham (66)**	Great Tindal Street	Extant	SP 05372 86842	Gauges small tools etc	Chatwin Ltd formerly occupied Victoria Works on Great Tindal Street, labelled on early OS maps, these buildings still stand.
1573455	National Gauge Factory	**Croydon (77)**	Gloucester Road	Unknown	TQ 3306 6668	Gauges	Vidal Engineering Co. The exact location of this gauge factory is uncertain but an 'iron works' is marked on the 1923 OS Map at TQ33066668 and may be the original site of the factory.
1573463	National Gauge Factory	**Kilburn (141)**	Fairfax Yard	Unknown	TQ 26285 84247	Gauges	The exact location of this gauge factory is uncertain and could not be identified on historic OS maps. Fairfax Yard may have been behind Fairfax Road at TQ 26285 84247. Fairfax Yard is shown on post-war maps at the north end of Fairfax Place, but appears to be residential.
1573459	National Gauge Factory	**Pimlico (128)**	Gatliff Road	Demolished	TQ 28565 78186	Gauges	Wolseley Motor Co. A 'motor depot' is marked on the historic OS on Gatliff Road but this no longer exists.
Not yet allocated	National Gauge Factory	**Walthamstow (202)**	Black Horse Lane	Extant	TQ 35732 90072	Gauges	Newall Engineering Co. This factory is known to have been sold to a dyeing and cleaning company in 1926. A large dyeing and cleaning works appears on the OS map of 1936. This may be the location of Newall gauge factory. Extant factory may have WW1 elements.
1573460	National Gauge Factory	**Woolwich (113)**	Upper Market Street	Demolished	TQ 43339 78770	Gauges	Pitter's Ventilating & Engineering Co. Building located on 1916 OS map, no longer extant.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
National Tool Factories							
Not yet allocated	National Tool Factory	**Gateshead (103)**	Coulthard's Lane		NZ 25818 63385	Spade cutters	Buildings forming the Close Engineering Works still stand south of Coulthards Lane, but it is not known if this was the exact location of the factory.
1575502	Small Tools Factory	**Westminster (186)**	14 Palmer Street	Demolished	TQ 29507 79457	Small tools	Coats Machine Tool Co. Factory building occupies site but it would appear to be of inter-war date.
1574651	National Ball Bearing Factory	**Chelmsford (156)**	Rectory Lane	Part extant	TL 7095 07545	Ball bearings	Hoffman Manufacturing Co. The 1921 OS map (1:2500) indicates that this factory was originally a huge complex comprising many buildings situated just to the north of Marconi Works. However the only building that remains extant is a long range that now comprises Globe House, Durrant Court and Ashby House of Anglia Ruskin University.
National Factories for Salvage Repair and Rectification							
Not yet allocated	Government Salvage Depot	**Blyth (181)**		Unknown		Storing and sorting salvage	No building has been identified corresponding with the salvage depot.
Not yet allocated	Government Salvage Depot	**Immingham (182)**		Unknown		Storing and sorting salvage	Location within the docks complex not confirmed.
1575494	Government Salvage Depot	**Ridham (185)**	Kent	Unknown		Storing and sorting salvage	The exact location of this Depot at Ridham, Kent, could not be established from Ordnance Survey maps, although it is likely to have taken up several of the dockyard buildings.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet allocated	Government Salvage Depot	**Trafford Park (183)**		Unknown		Storing and sorting salvage from overseas	No building has been identified.
1573416	National Cartridge and Box Repair Factory	**Dagenham Dock (98)**		Unknown		Repairing cartridges and ammunition boxes	The exact location of this factory could not be determined using historic OS maps.
1573384	Box Repair Factory	**Beddington (Trench Warfare) (117)**	Croydon	Demolished	TQ 30730 65522	Repairing bomb and grenade boxes	
1573111	National Gun Carriage Repair Factory	**Southampton (199)**	Empress Road	Unknown		Repairing gun carriages and breech mechanisms	The exact location of this factory could not be determined using historic OS maps, although it was apparently on or near Empress Road, Southampton. Possible building survives at south end of Empress Road (now Imperial Road).
1572638	National Fuse Rectification Factory	**Phoenix Factory (104)**	Grays Inn Road	Demolished	TQ 30993 82218	Repairing and rectifying fuses	Phoenix Foundry marked on 1916 map. Now demolished.

National Box Factories and Sawmills							
Not yet allocated	National Box Factory	**Castleford (158)**		Unknown		Making and repairing ammunition boxes	Location within Castleford unknown.
1572472	National Box Factory	**Leeds (159)**	Wellington Street	Unknown		Making and repairing ammunition boxes	J H Abrahams Ltd. Not possible to identify which warehouse relates to Abrahams. All remaining pre-WW1 buildings on Wellington Street are already listed.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet allocated	National Box Factory	**Lechworth (160)**		Unknown		Making and repairing ammunition boxes	Not possible to identify factory location.
1573117	National Box Factory	**Liverpool (161)**	Brasenose Road Bootle	Unknown		Making and repairing ammunition boxes	The exact location of this factory on Brasenose Road is uncertain. It could not be determined using historic OS maps. One timber yard is marked on the 1908 OS but this may not be the same business.
1573137	National Box Factory	**Luton (205)**		Unknown		Making and repairing tin boxes	The exact location of this factory is uncertain. It was probably at Chaul End where the Ministry had a National Fuse Filling Factory.
1573429	National Box Factory	**Willesden (125)**	Park Royal	Demolished	TQ 19500 82500	Making and repairing ammunition boxes	
1573136	National Box Factory	**Woolwich (122)**	Trinity Street	Unknown		Making and repairing ammunition boxes	Watt Torrance & Co. The exact location of this factory on Trinity Road (now Warspite Road) is uncertain. The 1896 OS map indicates a possible industrial building/ warehouse at TQ42027924, which may have been utilised in 1916.
1573115	National Box Factory	**Guildford (206)**	Walnut Tree Close	Unknown		Making and repairing tin boxes	The exact location of this factory at Walnut Tree Close could not be determined using historic OS maps, although there is a possible complex of industrial buildings at SU99154994.
Not yet allocated	National Box Factory	**Maidstone (204)**		Unknown		Making and repairing tin boxes	

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
Not yet allocated	National Box Factory	**Deptford No. 1 (123)**	Pier Warf	Unknown	TQ 37330 78056	Making and repairing tin boxes	A 'Tin Box and Packing Case Works' is shown on the 1916 OS on the waterfront at Butchers Row (now Borthwick Street). Site now occupied by an electricity substation.
Not yet allocated	National Box Factory	**Deptford No. 2 (188)**	Kent Wharf	Demolished	TQ 37626 77468	Making and repairing tin boxes	Kent Wharf is on the west bank of Deptford Creek. The site has been redeveloped.
Not yet allocated	Non-Returnable Box Depot	**Erith (139)**	Cory's Wharf, Belvedere	Demolished	TQ 51262 78333	Repairing and converting non-returnable boxes	A steam sawmill is depicted on both pre- and post-war OS. Adjacent to the area of Cory's Wharf. Whole area now demolished and re-developed.
Not yet allocated	Non-Returnable Box Depot	**Willesden (140)**	Park Royal	Unknown		Repairing and converting non-returnable boxes	Park Royal complex is very large, no particular building identified associated with this process.
1573373	National Sawmill	**Berwick (197)**	Tweed Sawmills	Demolished	NT 99118 51263	Sawing timber	Messrs Allan Brothers. Site of Tweed Saw Mill shown on 1924 OS now demolished.
1573144	National Sawmill	**Gloucester (173)**	Bristol Road	Demolished	SO 82431 17292	Sawing timber	Messrs Joseph Griggs & Co. Depicted on historic OS, now demolished.
1573143	National Sawmill	**Luton (176)**	Dunstable Road	Demolished	TL 08397 21508	Sawing timber	Messrs Henry Brown & Co. Depicted on historic OS, now demolished.
1573383	National Sawmill	**Poole (172)**	Hamworthy	Possibly part extant	SZ 00389 90287	Sawing timber	Messrs J T Sydenham & Co. A timber yard is shown on the 1890, 1902 and 1925 OS Maps just to the north of Hamworthy Railway Station on Blandford Road. This seems to be the likely position for the First World War sawmill. There is still a sawmill at the same location, part of which may include the original buildings.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
1573145	National Sawmill	**Rotherhithe (142)**	Plough Road	Demolished	TQ 36387 78813	Sawing timber	Messrs Priddy & Hale. This saw mill first appears on the 1896 OS map (1:2500), although there is a timber yard at this location on the 1874 OS map. The buildings are now largely demolished but one possibly survives at TQ3635778750 having been extended to the east. Two timber yards are present on Plough Road on historic OS, both now demolished.
1573376	National Sawmill	**Southampton (171)**	Northam	Demolished	SU 43378 12814	Sawing timber	Messrs Driver & Co. saw mill marked on historic OS, now demolished.
1573381	National Sawmill	**Warrington (175)**	Walton Lay Bye	Demolished	SJ 60047 86149	Sawing timber	Messrs R A Naylor Ltd
Mine Sinker Assembly Station							
602472	Mine Sinker Assembly Station	**Cowley (133)**		Part extant	SP 54707 04316	Assembling naval mine sinkers	WRM Motors Ltd. The original building used as the Morris car factory still stands and is listed Gr II. The 1925 OS shows an adjacent building matching the dimensions for the mine factory given in Official *History* but this is now demolished.
National Machine Gun Factory							
922427	National Machine Gun Factory	**Burton on Trent (163)**		Extant	SK 23351 21441	Repairing machine guns	Factory on Burton Road, Branston subsequently became Branston Pickle factory. Several buildings extant and Listed.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
National Factories for Optical Munitions							
1575029	National Optical Munitions Factory	**Kentish town (198)**	23 Prince of Wales Crescent	Demolished	TQ 28471 84582	Optical instruments	Prince of Wales Crescent no longer exists, whole area redeveloped.
1575036	National Photographic Lens Factory	**Brimsdown (214)**	Green Street, Enfield	Demolished	TQ 36118 96871	Photographic lenses	Whole area redeveloped.
National concrete and Steel Billet Breaking Factories							
1575049	Concrete Slab Factory	**Gotham (211)**	Nottinghamshire	Demolished	SK 53466 29368	Plaster slabs	J A King & Co. Plaster factory is shown on OS along with slab factory. Slab factory site now demolished but undeveloped, factory footprint appears as crop mark.
1575053	Concrete Slab Factory	**Yate (212)**	Gloucestershire	Demolished	ST 69949 82452	Concrete slabs	Robert MacAlpine & Sons. On 1921 OS map, now demolished.
Not yet allocated	Steel Billet Breaking Factory	**Trafford Park (121)**	Unknown			Breaking steel billets to shell lengths	No site associated with this factory has been identified in Trafford Park.

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
National Rifle Factory							
1573479	National Rifle Factory	**Birmingham no. 1 (209)**	Lench Street	Demolished	SP 07394 87609	Intended to assemble parts for the Farquhar Hill rifle	Standard Small Arms Co. The exact location of this factory is uncertain but there is a large building, possibly a factory, at SP0730587607 on the 1917 OS map. These are the only buildings on Lench Street. The factory was both sides of the road. Whole area now demolished.
1573480	National Rifle Factory	**Birmingham no. 2 (210)**	Garrison Lane	Unknown		Intended to assemble parts for the Farquhar Hill rifle	Standard Small Arms Co. The exact location of this factory could not be determined using historic OS maps. Several possible locations can be identified on Garrison Lane but none of these buildings survive.
Scotland Wales & Ireland							
National Factories for Salvage Repair and Rectification							
	Government Salvage Depot	**Renfrew (184)**				Storing and sorting salvage	
	National Cartridge and Box Repair Factory	**Alexandra dock (138)**	Newport			Repairing cartridges and ammunition boxes	

© HISTORIC ENGLAND

NRHE UID	Historic classification	Title	Address/ Location	Condition	NGR	Output	Notes
National Box Factories and Sawmills							
	National Box Factory	**Paisley no. 1 (162)**	Caledonia Sawmills			Making and repairing ammunition boxes	
	National Box Factory	**Paisley no. 2 (207)**	Mc Kean Street			Making and repairing tin boxes	
	National Box Factory	**Glasgow (187)**	Salamanca Street, Parkhead			Making and repairing tin boxes	
	National Sawmill	**Dumfries (174)**	Leafield			Sawing timber	
	National Sawmill	**Elgin (168)**	Morayshire Sawmills			Sawing timber	
	National Sawmill	**Glasgow (143)**	45 Milton Street			Sawing timber	
	National Sawmill	**Glasgow (154)**	Whiteinch			Sawing timber	
	National Sawmill	**Inverness (167)**	The Sawmills			Sawing timber	
	National Sawmill	**Kilmarnock (155)**	Bonington Road			Sawing timber	
	Rolling Mills and Blast Furnaces	**Merthyr Tydfil (190)**	Cyfarthfa			Basic pig iron, rolling 18pdr shell steel bars	Crawshay Bros Ltd.

APPENDIX B DESK-BASED ASSESSMENTS OF SURVIVING FACTORIES

List of sites with surviving structures:

Royal Ordnance Factories (ROF)

Royal Ordnance Factory

Woolwich (1)

Royal Small Arms Factory

Enfield (2)

Royal Gunpowder Factory

Waltham Abbey (3)

HM Explosives Factories (HMEF)

Gretna (31)

Swindon (119)

Wood Distillation and Acetone Factories

Ludlow(201)

National Cotton Waste Mills

Greenfield (148)

Hadfield (149)

Rawtenstall (Constable Lee Mill) (151)

Woodley (153)

National Shell Factories (NSF)

Birmingham (13)

East Cumberland (Carlisle) (56)

Leeds NFF (Armley Road NOF. No. 4) (96)

Liverpool (Cunard) (19)

Manchester (94)

Metropolitan (Ailsa Craig) (109)

Rawtenstall and Bacup No. 1 (82)

Rochdale (72)

National Projectile Factories (NPF)

Birtley (41)

Dudley (42)

Sheffield (Templeborough) (53)

NOF New Basford (179)

National Filling Factories (NFF)

Banbury No. 9 (83)

Chillwell No. 6 (48)

Coventry No. 10 and 21 (35)

Gainsborough No. 22 (178)

Hereford No. 14 (108)

Leeds No. 1 (63)

Liverpool No. 2 (34)

Morecambe No. 13 (50)

Trench Warfare Filling Factories (TWFF)

Chemical Shell Filling

TWFF (Chemical) Walthamstow (107)

Government Factories for Cartridges and Small Arms Ammunition

Government Cartridge Factory (GCF)

No. 3 Blackpole (101)

National Factories for Aircraft Production

Royal Aircraft Factory

Farnborough (4)

National Aircraft Factory

Heaton Chapel (165)

Aero-Engine Factory

Ladbrook Grove (193)

Hayes (166)

National Radiator Factory

Sudbury (196)

Chemical and Anti-Gas Factories

Anti-Gas Factories

Holloway (Batavia Mills) (217)

Holloway (Holloway Mills) (218)

Miscellaneous National Factories

National Gauge Factories

Birmingham (66)

Walthamstow (202)

National Tool Factories

Chelmsford (National Ball-bearing Factory) (156)

National Sawmills

Poole (172)

Mine Sinker Assembly Station

Cowley (133)

National Machine Gun Factory

Burton-on-Trent

Modern Ordnance Survey mapping:

© Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900.

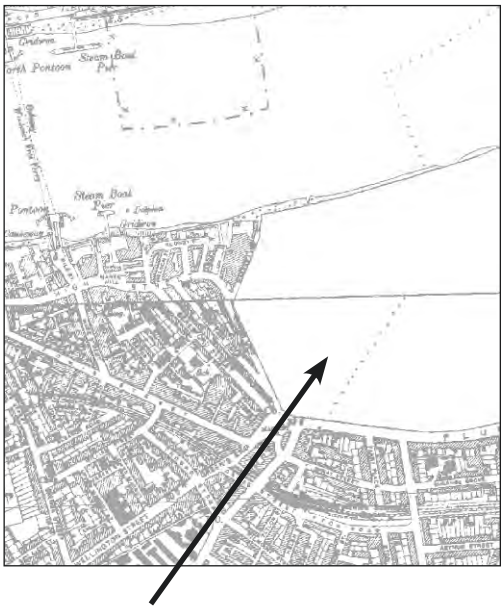
Historic Ordnance Survey mapping:

© Land database right Crown Copyright and Landmark Information Group Ltd (All rights reserved 2015). Licence numbers 000394 and TP0024.

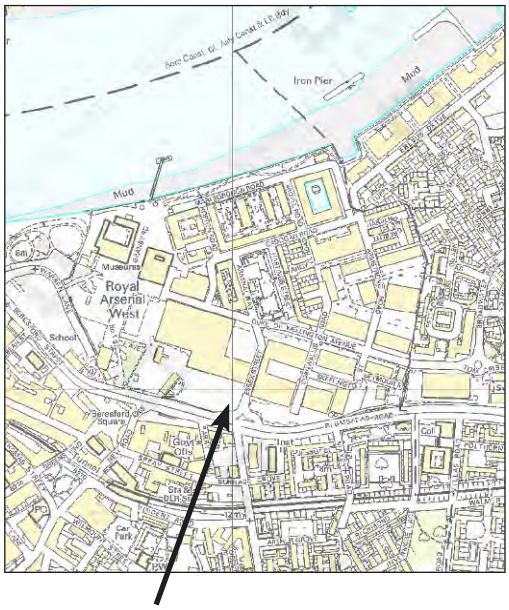
Royal Arsenal Woolwich (1)	Beresford Street, Woolwich, London
Surviving structure: **Various Factory Buildings** Status: Listed Gr II	NGR TQ 43996 79200 NHRE No. 911843 and 911656

Beresford Gate 1996 (English Heritage K96063)

Historic Site Plan
OS 1:10,560 London 1919



Modern Location Map



Description/additional images

The history of the Royal Arsenal at Woolwich dates back to the 1690s when the Royal Laboratory was moved here from Greenwich for the making of ammunition. This was followed by gun-making in 1717, and by 1914 the western part of the site was a dense complex of mostly 19th-century factories and workshops.(1)

In 1914 the site was divided into four departments:
The Royal Laboratory, where ammunition was made and filled.
The Royal Gun Factory and Carriage Department, dealing with gun manufacture as well as carriages, transport and boxes.
The Mechanical Engineers' Department, which dealt with the engineering requirements of the Arsenal.
Building Works Department, responsible for buildings work and rail traffic.
These existing departments occupied the western part of the site, but wartime expansion, especially of 'Danger' buildings, was carried out on the marshes to the east of the site. This included small arms ammunition and fuse factories as well as the new gun factory. (2)

Much of the 19th-century site is preserved, and a number of buildings are listed, however none of the First World War period expansion buildings to the east survives, this area has been redeveloped.

Sources:

(1) Guillery, P, (Ed) 2012 *Survey of London,* 48, *Woolwich* (English Heritage/Yale UP, London) p. 129

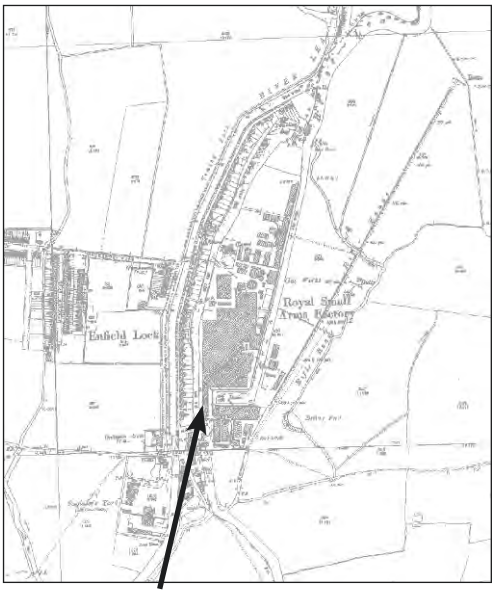
(2) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 9

RSAF Enfield Lock (2)	Enfield Island Village, Enfield, Middlesex
Surviving structure: **Factory and Offices** Status: Listed Gr II	NGR TQ 37258 98512 NHRE No. Not Allocated

(Christine Matthews [CC BY-SA 2.0 http://creativecommons.org/licenses/by-sa/2.0], via Wikimedia Commons)

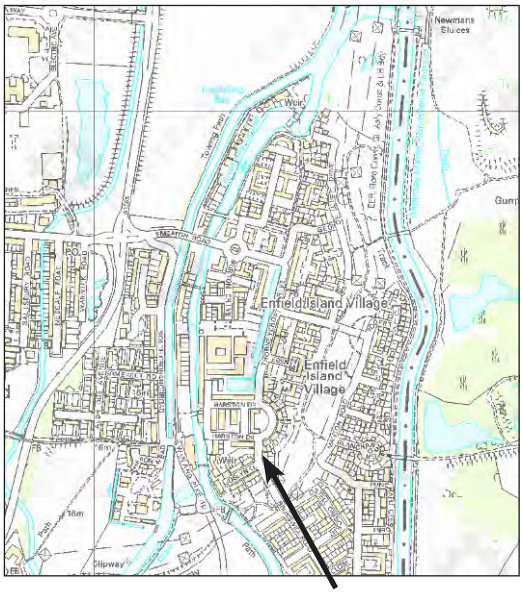
Historic Site Plan

OS 1:2,500 map Middlesex 1897



Factory buildings

Modern Location Map



Surviving buildings

Description/additional images

The Royal Small Arms Factory was established in 1804 for the manufacture of military firearms. The factory was rebuilt in 1857-8 and many of these buildings survived in 1914. At the start of the war the site was principally concerned with the manufacture of the SMLE rifle, along with cavalry swords and other edged weapons. Initially 1,000 rifles were manufactured and a similar number repaired per week, but by 1915 this had risen to 6,000 per week. By April 1918 there were 9,554 employees of whom 1,404 were women.
The factory was expanded in 1917 by the addition of a number of new buildings especially on the east side of the site. These included a canteen, and recreation and welfare rooms for women workers. (1)

Several of the original 1858 buildings survive and form part of 'Enfield Island Village', including a machine shop and associated office buildings, and two terraces of worker's cottages. These buildings are Listed Gr II. No buildings built during the First World War expansion survive on the site.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 28-36

RGPF Waltham Abbey (3)	Beaulieu Drive, Waltham Abbey, Essex
Surviving structure: **Factory Buildings** Status: Listed Gr I and II, Scheduled	NGR TQ 37674 01400 NHRE No. 1010269

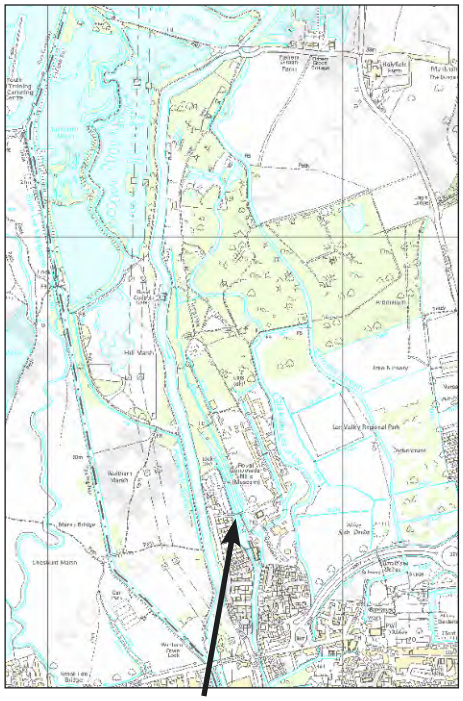
L134. (W Cocroft)

Historic Site Plan

OS 1:2,500 map Essex 1923

RGPF Waltham Abbey

Modern Location Map



RGPF Waltham Abbey

Description/additional images

Gunpowder had been manufactured at Waltham Abbey since the 16th and 17th centuries. The Royal Gunpowder Factory (RGPF) was established in 1787. In the 1890s the site switched to the production of cordite, supplying about 70 tons per week by 1914.
This production was massively expanded from 1914 onwards such that over 30,000 tons of cordite were produced during the war. The site also produced tetryl (CE) for use in fuses, as well as small quantities of gunpowder. In March 1918 the site employed 5,730 people, of whom 2,277 were women. (1)

Production of guncotton and cordite was carried out in purpose-built factories at Quinton Hill, now all demolished, and in converted gunpowder buildings, as well as other specialist structures on the surviving North Site. Much of this building stock originated from an expansion of the factory in the 1860s. In addition to pre-existing buildings a number of First World War period buildings were erected. These included cordite mixing and pressing houses, as well as drying stoves, and the associated narrow gauge rail infrastructure. A women's hospital, and canteens and shifting rooms were also constructed. (2)

Much of the cordite factory survives, including pre-war buildings (some Listed Gr I and II) as well as wartime structures. Drying stoves and other facilities also survive on other parts of the site. The hospital and canteens have been demolished.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 77-78

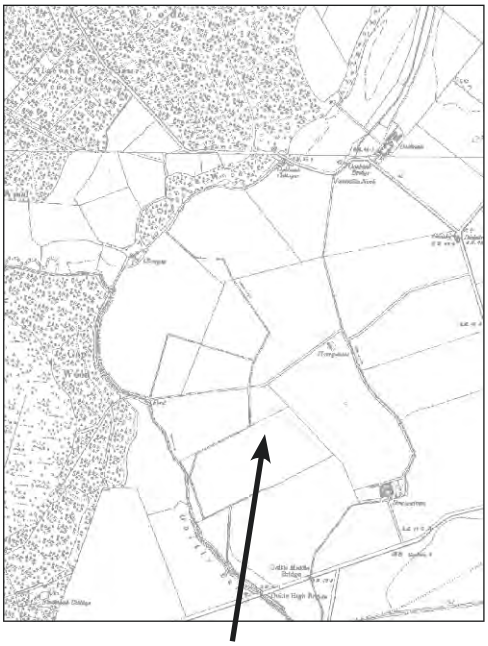
(2) Cocroft, W, 2000, *Dangerous Energy*, *The archaeology of gunpowder and military explosives manufacture* (English Heritage, Swindon) pp. 155-194

HMEF Gretna (31)	Longtown, Cumbria
Surviving structure: **Magazines** Status: Non-designated	NGR NY 35491 66936 NHRE No. 1087349

No current image of this structure is available.

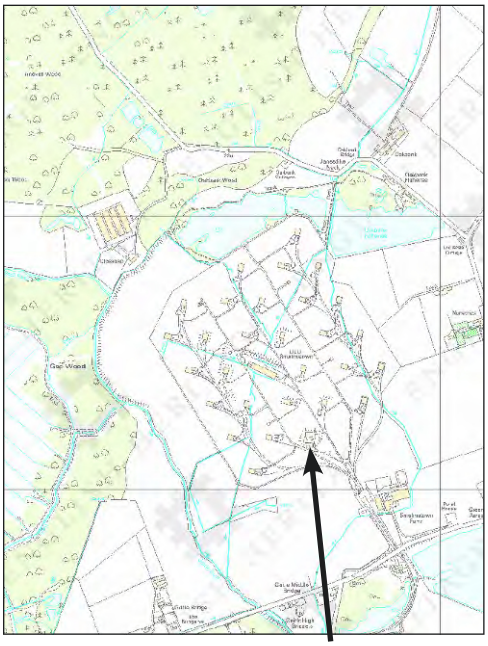
Historic Site Plan

OS 1:10,560 map Cumberland 1901



HMEF Gretna

Modern Location Map



HMEF Gretna

Description/additional images

A National Factory was established at Gretna in 1915 for the production of cordite. The site stretched 12km straddling the English and Scottish border between Dornock, Dumfries and Galloway, in the west, and Longtown, Cumbria, in the east. It was the largest explosives factory in the British Empire, employing 19,772 people at its height in October 1917, with a projected capacity of 40,000 tons of cordite per year. The total cost of the factory was £9,295,000. Gretna was self-sufficient in the manufacture of sulphuric and nitric acid and also had its own glycerine distillery. The acids section was located at Dornock at the west end of the factory with raw material stores for sulphur, pyrites, and nitre. The production flow moved from west to east. Adjacent to the acid plant was the guncotton section. At Mossband to the east were the cordite incorporating and pressing plant and magazines for finished product. (1)

Surviving structures on the English side of the border lie within the subsequent Government munitions depot. These consist of possibly 1914-18 magazine buildings at Smalmstown.

On the Scottish side, two guncotton drying stoves are extant along with various buildings within the Gretna and Eastriggs townships.

Sources:

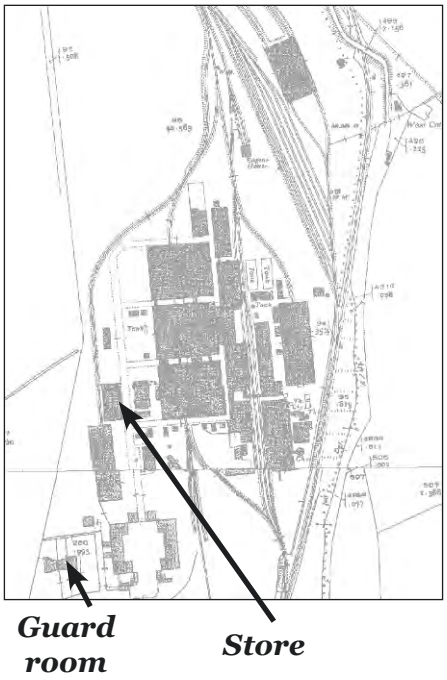
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 58-60

HMEF Swindon (Stratton Works) (119)	Bramble Road, Stratton St Margaret, Swindon, Wiltshire
Surviving structure(s): **Stores building?** Status: Non-designated	NGR SU 16387 86380 NHRE No. 1075159

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Wiltshire



Modern Location Map

Description/additional images

Construction of a factory to produce ammonium nitrate under direct government control was begun in early 1917. The site had the capacity to produce up to 1,600 tons per week but never ran at 'all out', typically producing 500 tons per week. In October 1918 there were 1,246 employees of whom 37.8% were women. (1)

The principal process buildings lay to the east of the surviving building and are now demolished, along with the quadrangle of administrative buildings to the south.
The function of the northern surviving building is unknown but it is likely to have been a store or non-chemical workshop. The original tall windows on the ground-floor level appear to have been replaced by smaller openings.

The southern building, now a pair of bungalows, appears to have been a guard room or security lodge.

Details from Official *History* are repeated in TNA File (2)

Wartime photos of site and description in *RIBA Journal* article. (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 77-78

(2) "State manufactury of ammonium nitrate" TNA MUN5/365 (4pp)

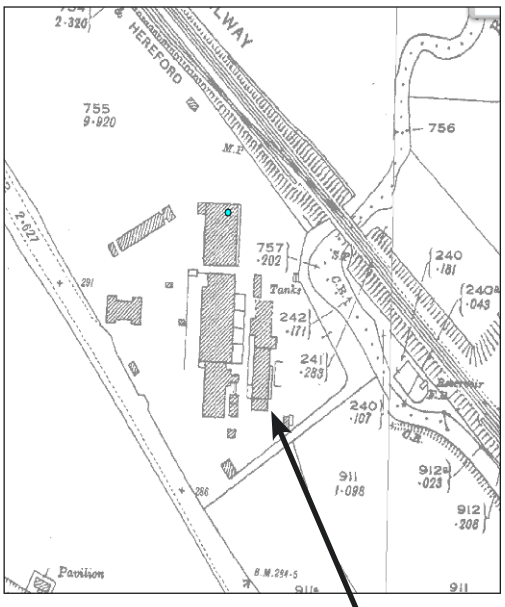
(3) Baines, F, 1919 'War Factories and Sheds' in *RIBA Journal*, Vol. XXVI Third Series (London) pp. 230-232

HMEF Ludlow (Wood distillation & Acetone) (201)	(Ludlow Motors), Bromfield Road, Ludlow, Shropshire
Surviving structure: **Factory** Status: Non-designated	NGR SO 50836 75602 NHRE No. 1075568

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Shropshire 1926



Possible surviving buildings

Modern Location Map

Possible surviving buildings

Description/additional images

Ludlow was one of three factories for the distillation of acetone planned in October 1917. The others were at Mid Havant and Carmarthen. The acetone was required as dope for aircraft manufacture; however the plants did not go into production before the Armistice. (1)

Correspondence held at TNA describes the site as 'just outside the town on a strip of land between the main road and the railway'. (2)

Elsewhere archival sources suggest it was '½ mile north of the railway station'. (3)

A plant appears on OS maps post war at SO 50836 75602, of which some buildings appear to be still standing.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 77-78

(2) Correspondence in TNA MUN4/6053

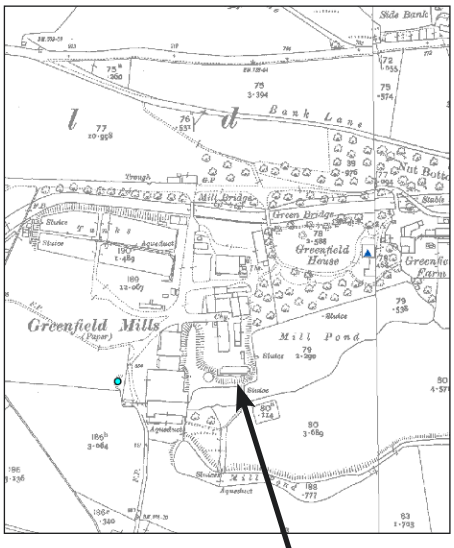
(3) 'Policy re disposal of H M Wood Distillation factories at Bideford, Coleford, Longparish, Ludlow and Mid-Havant' TNA MUN4/6187

HM Cotton Waste Mill Greenfield (148)	Holmfirth Road, Greenfield, Oldham, Yorkshire
Surviving structure: **Factory Building** Status: Non-designated	NGR SE 00879 03651 NHRE No. 1076776

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Yorkshire 1932



Possible surviving buildings

Modern Location Map

Possible surviving buildings

Description/additional images

At the outbreak of war the majority of cotton waste supplies in the UK were controlled by the British and Foreign Supply Association. 300 tons of waste were supplied weekly by the association for the national cordite factories until in May 1918 when the mills in question were taken in to direct government control. In 1917 Greenfield mill was also used for experimentation in connection with nitrocellulose powder production. (1)

Greenfield Mill was converted to a paper mill and continued until the mid-2000s, currently derelict, may include 1914-1918 period features.

Britain From Above image showing site in 1950 (2)

Sources:

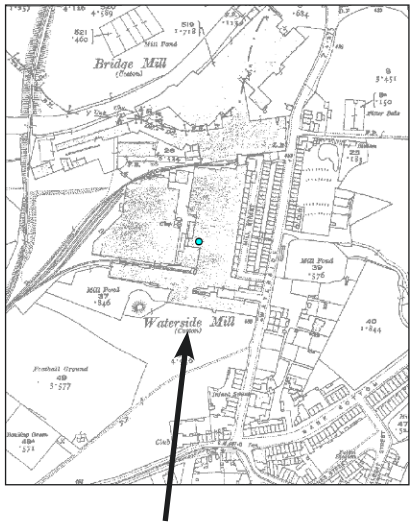
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 86

(2) http://www.britainfromabove.org.uk/image/EAW032430

HM Cotton Waste Mill Hadfield (149)	Waterside Mill, Waterside, Hadfield, Derbyshire
Surviving structure: **Mill Buildings** Status: Non-designated	NGR SK 01953 96658 NHRE No. 1364763

Part of mill, now demolished. (English Heritage BF055199)
Other buildings may survive.

Historic Site Plan
OS 1:2,500 map Derbyshire 1922



HM Cotton Waste Mill Hadfield

Modern Location Map

HM Cotton Waste Mill Hadfield

Description/additional images

At the outbreak of war the majority of cotton waste supplies in the UK were controlled by the British and Foreign Supply Association. 300 tons of waste were supplied weekly by the association for the national cordite factories until in May 1918 when the mills in question were taken in to direct government control. (1)

Site is marked on wartime OS mapping. Some building footprints match so parts may be extant.

Sources:

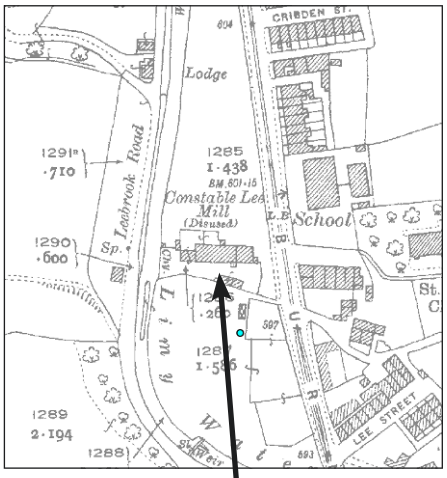
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 86

HM Cotton Waste Mill Rawtenstall (Constable Lee Mill) (151)	Constable Lee Mill, Burnley Road, Rawtenstall, Lancashire
Surviving structure: **Mill Building** Status: Listed Grade II	NGR SD 80938 23791 NHRE No. 1575855 1078684

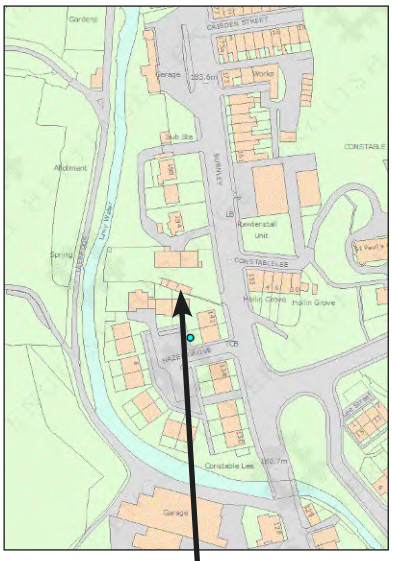
Nov 2007 (English Heritage IoE 185737)

Historic Site Plan

OS 1:2,500 map Lancashire 1930



Modern Location Map



Description/additional images

At the outbreak of war the majority of cotton waste supplies in the UK were controlled by the British and Foreign Supply Association. 300 tons of waste were supplied weekly by the association for the national cordite factories until in May 1918 when the mills in question were taken in to direct government control. (1)

Constable Lee Mill survives, currently occupied by a scrap merchant. The mill building is listed Grade II.

Sources:

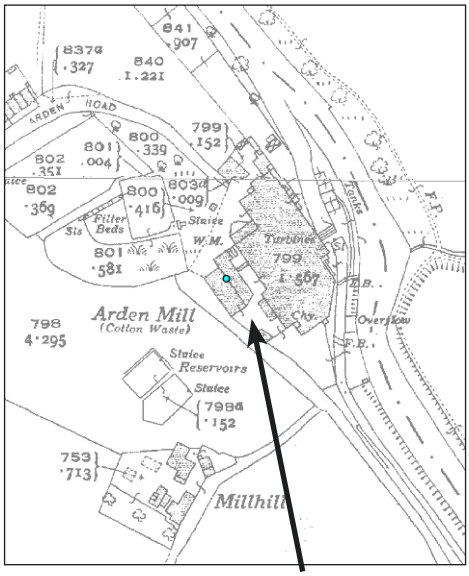
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 86

HM Cotton Waste Mill Woodley (153)	Arden Mill, Arden Road, Woodley, Lancashire
Surviving structure(s): **Mill buildings** Status: Non-designated	NGR SJ 92669 93371 NHRE No. 1076877

No current image of this structure is available.

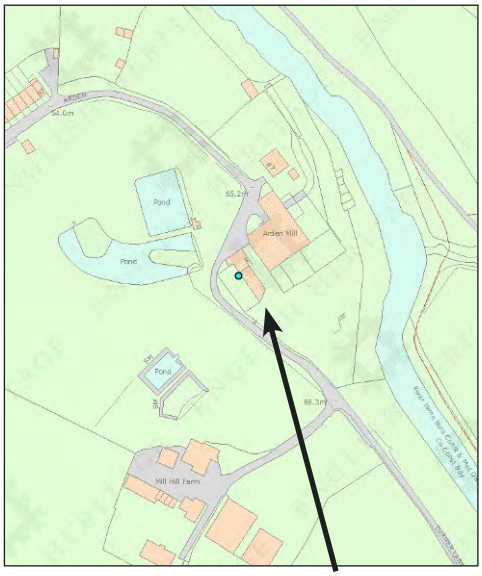
Historic Site Plan

OS 1:2,500 map Lancashire 1934



HM Cotton Waste Mill Woodley

Modern Location Map



HM Cotton Waste Mill Woodley

Description/additional images

At the outbreak of war the majority of cotton waste supplies in the UK were controlled by the British and Foreign Supply Association. 300 tons of waste were supplied weekly by the association for the national cordite factories until in May 1918 when the mills in question were taken in to direct government control. (1)

Mill is labelled on historic OS map, but is now derelict and decaying rapidly.

Sources:

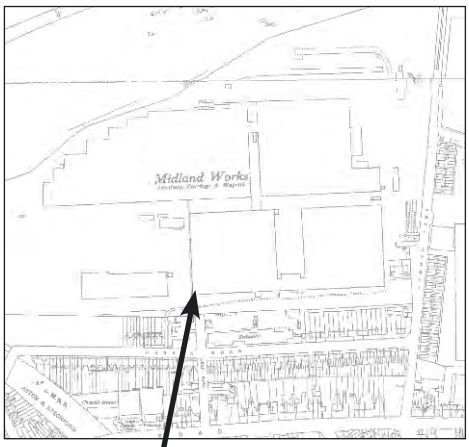
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 86

National Shell Factory Birmingham (13)	Midland Works, Washwood Heath, Birmingham
Surviving structure**: Factory** Status: Non-designated	NGR SP 10441 89195 NHRE No. 1572642

No current image of this structure is available.

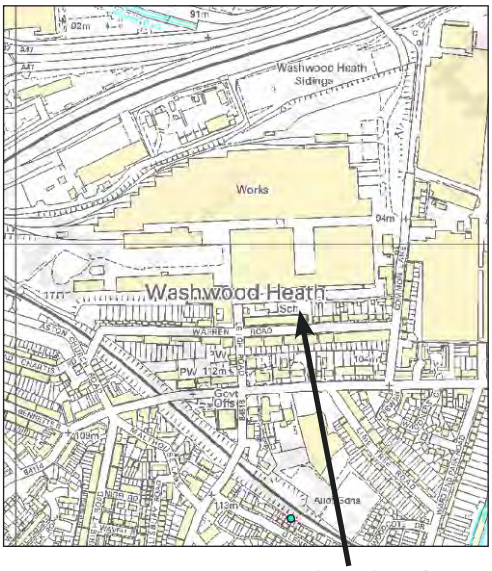
Historic Site Plan

OS 1:2,500 map Warwickshire 1937



NSF Birmingham

Modern Location Map



NSF Birmingham

Description/additional images

In June 1915 parts of the Midland Railway Company Carriage Works at Washwood Heath were taken over for the manufacture of 4.5in shell. Additional premises were also acquired in 1916. Some work was also carried out on 18pdr and 9.2in shell. In 1916 a maximum capacity of 12,000 shells per week was attained. Maximum number of employees was reached in November 1917 at 2,400 of whom 66% were women. (1)

Britain From Above image showing site (bottom left) 1930 (2)

The factory appears to be substantially intact and is still used by ALSTOM for train manufacture.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p94-6

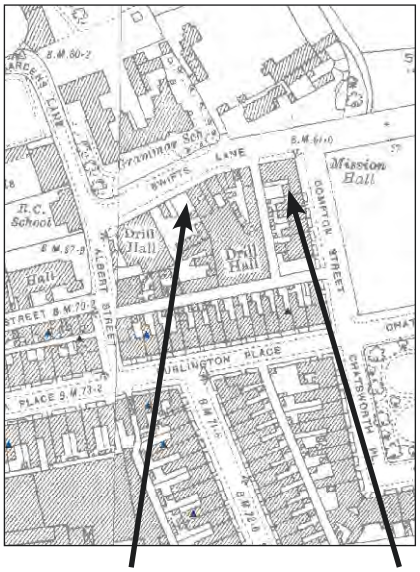
(2) http://www.britainfromabove.org.uk/image/EPW031308

National Shell Factory East Cumberland (Carlisle) (56)	Drill Hall, Strand Road, Carlisle
Surviving structure: **Drill hall and Canteen** Status Non-designated	NGR NY 4041 5612 NHRE No. 1572916

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Cumberland 1925



Surviving frontage ***Canteen***

Modern Location map

Surviving frontage ***Canteen***

Description/additional images

East Cumberland NSF was established in September 1915 in a Rifle Drill Hall. The nearby TA Drill Hall was also taken over as stores, and an adjacent mission hall was converted into a canteen. A house was also occupied. The factory produced 4,000 18pdr shells per week at its peak in 1917. Employees numbered 257 in October 1918, of whom 81.3% were women. (1)

OS maps from 1925 show two drill halls, only the easterly of which now survives. The Mission Hall on the eastern corner of the block also survives.

The surviving building is identified by the *Cumberland News* as the Rifle Drill Hall, which opened in 1874. (2)

It would appear that the frontage of the drill hall survives but the hall itself was demolished in 2013. (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 99

(2) http://www.cumberlandnews.co.uk/war-office-fought-for-control-of-carlisle-drill-hall-1.784415

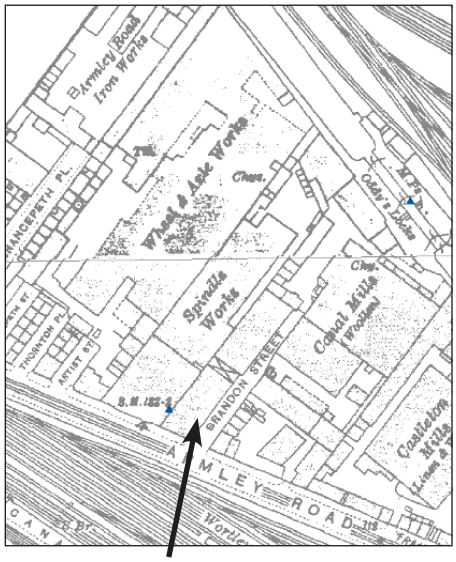
(3) https://www.flickr.com/photos/lakewalker/9250359776/

National Fuse Factory Leeds Armley Road (NOF No. 4) (96)	Brandon Street, Leeds, Yorkshire
Surviving structure: **Factory** Status: Non-designated	NGR SE 28519 33456 NHRE No. 1572469

No current image of this structure is available.

Historic Site Plan

OS 1:25,000 map Yorkshire 1921



Surviving building

Modern Location Map

Surviving building

Description/additional images

Early in 1916 the Leeds Board of Management took over manufacture of No.106 fuse from the Leeds Munition Company and transferred the work to the former spindle works of Jonathan Hattersley and Sons. Work was also shared by sites at Wellington Street (NOF No. 5) and Sweet Street (NOF No. 6). Together they produced up to 100,000 fuses per week in 1918. Staff at the three sites numbered 1,470 in October 1918 of whom 86.2% were women. (1)

A former spindle factory adjacent to Brandon Street is marked on pre-war OS maps. The buildings occupying this site are possibly early 20th-century.

Sources:

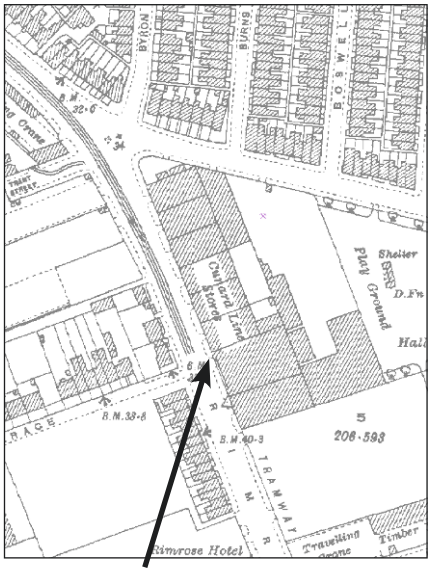
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 107-108

National Shell Factory Liverpool (Cunard) (19)	Cunard Co. Rimrose Road, Bootle, Liverpool
Surviving structure: **Factory building** Status: Non-designated	NGR SJ 33220 96140 NHRE No. 1078897

(W Cocroft)

Historic Site Plan

OS 1:2,500 map Lancashire 1927

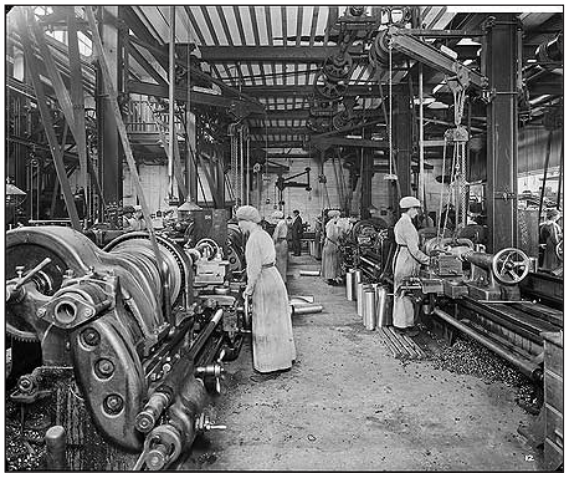


Modern Location Map

Description/additional images

In June 1915 a stores building owned by the Cunard Steamship Company was taken over to establish a National Shell Factory. The building was extended to the rear and an additional internal storey added with a concrete and girder floor. Originally intended to work on 4.5in shell the factory also produced 6in and 8in. In October 1918 the site employed 1,110 people of whom 73.8% were women. (1)

HE online archive has a series of interior photos. (2)(3)



Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 108-109

(2) Cocroft, W D and Leith, I 1996 'Cunard's Shellworks, Liverpool' *Archive* **11**, 53-64

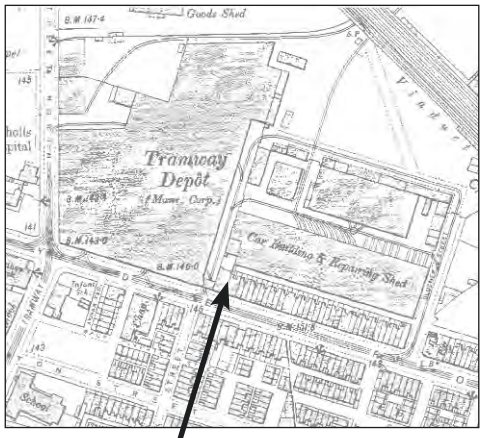
(3) http://www.englishheritagearchives.org.uk

National Shell Factory Manchester (94)	Tramway Depot, Hyde Road, Manchester
Surviving structure: **Tram depot** Status: Non-designated	NGR SJ 85865 97009 NHRE No. 1572983

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Lancashire 1908



Factory building

Modern Location Map

Factory building

Description/additional images

In October 1915 Hyde Road Tram depot was taken over rent free from Manchester Corporation for the establishment of a shell factory. At peak in 1917 the factory produced 2,000 4.5in shells per week. The number of employees in October 1918 was 252, of whom 79% were women. (1)

Historic OS maps indicate that the Tram Depot was constructed sometime between 1893 and 1908 and is still largely extant. The street frontage of the tram depot itself appears to have been modernised. The condition of rear structure is unknown but possibly original.
The adjacent car shed appears also to be extant.

Sources:

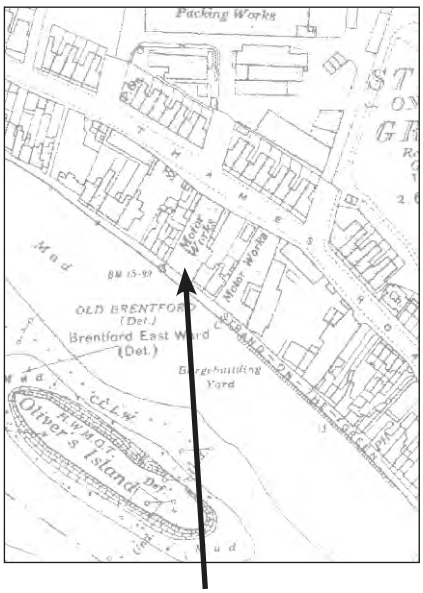
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 108-109

National Shell Factory / National Projectile Factory Metropolitan (Ailsa Craig) (109)	46 Thames Road, Strand on the Green, Chiswick
Surviving structure: **Factory** Status: Non-designated	NGR TQ 19492 77743 NHRE No. 1575744

No current image of this structure is available.

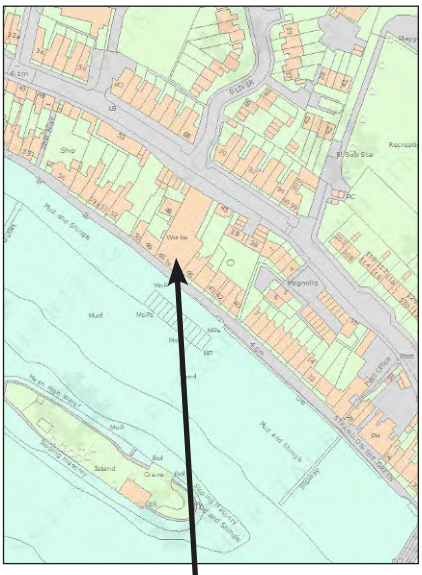
Historic Site Plan

OS 1:2,500 map Middlesex 1915



Factory

Modern Location Map



Factory

Description/additional images

Formerly the motor works of the Alisa Craig Motor Company, this plant had already been producing 4.5in shell when it was taken over by the government in July 1916. Output reached as high as 5,000 shells per week in 1917. The number of employees in March 1918 was 608 of whom 54.9% were women. (1)

The factory building is depicted on historic mapping and appears to survive complete.

Sources:

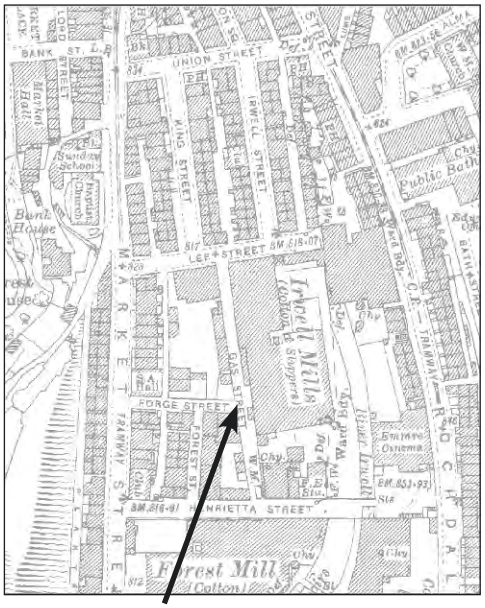
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.111-112

National Shell Factory Rawtenstall and Bacup No. 1 (82)	Irwell Mill, Gas Street, Bacup
Surviving structure: **Mill building** Status: Non-designated	NGR SD 86902 22740 NHRE No. 1574492

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Lancashire 1910



Mill building

Modern Location Map

Location of mill building

Description/additional images

In December 1915 a single-storey weaving shed at Irwell Mill was given rent free for use as a shell factory. Up to 2,000 4.5in shells were produced per week. In October 1918 the number of employees was 180 of whom 65.6% were women. (1)

Cartographic evidence indicates that the current building on the site resembles the footprint of the southern part of the original. It may therefore still be part-extant. The eastern core of the mill has been refurbished for NHS offices.

Sources:

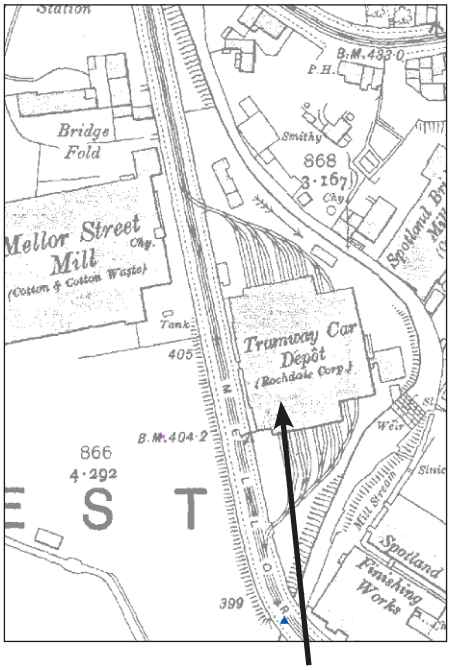
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.115

National Shell Factory Rochdale (72)	Corporation Tram Depot, Mellor Street, Rochdale
Surviving structure: **Tram Depot** Status: Non-designated	NGR SD 88661 13630 NHRE No. 1572986

No current image of this structure is available.

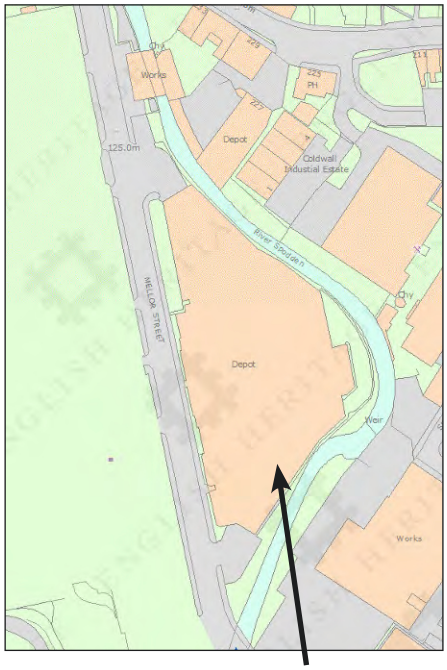
Historic Site Plan

OS 1:2,500 map Lancashire 1910



Shell factory

Modern Location Map



Shell factory

Description/additional images

In November 1917 part of the recently constructed Rochdale tram depot was taken over as a shell factory. Maximum output of 1,000 6in shells per week was reached in late 1916. In October 1918 the site employed 289 people of whom 70.9% were women. (1)

The building appears to have been extended but the central core and monumental office frontage appear to be original.

Sources:

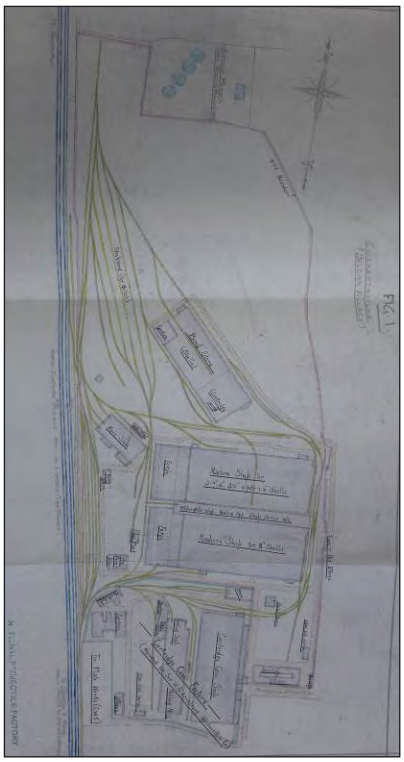
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.116

National Projectile Factory Birtley (41)	Edward Road Birtley Co. Durham (Tyne & Wear)
Surviving structure: **Factory building** Status: Non-designated	NGR NZ 26697 56098 NHRE No. 1575582

First World War canteen. (W Cocroft)

Historic Site Plan

Site Plan TNA MUN 5/157



Modern Location Map

Factory site now cleared

Description/additional images

A National Projectile Factory was established on a 52-acre site at Birtley from July 1915 by the armament firm Messrs. Armstrong Whitworth. It was suggested that the factory should be worked by Belgian labour and in February 1916 an agreement was signed between the British and Belgian Governments. After it was built in April 1916 Messrs. Armstrong relinquished control to the Belgian Government. The staff included over 1,000 skilled men released from the army, and rose as high as 3,826 workers, including very few women, on day and night shifts. By February 1917 production had reached 4,000 8-inch, 8,000 6-inch, and 6,000 60-pdr shells per week. By the end of the war over 2.8 million shells had been manufactured. Work closed down almost immediately after the Armistice in November 1918. (1)

The southern portion of the main workshop, the '8" Machine shop' survives although surrounded by later buildings. A number of other structures including a canteen and at least one transformer building also survive.

The street plan of the associated 'Elizabethville' workers housing survives to the north east. Two timber buildings forming part of the town survive on Devon Crescent. These were formerly the butcher's shop and grocery store. They are currently occupied by a car repair garage.

A full history of the site with detailed plans and process diagrams survives in TNA (2)

Sources:

Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 131-133

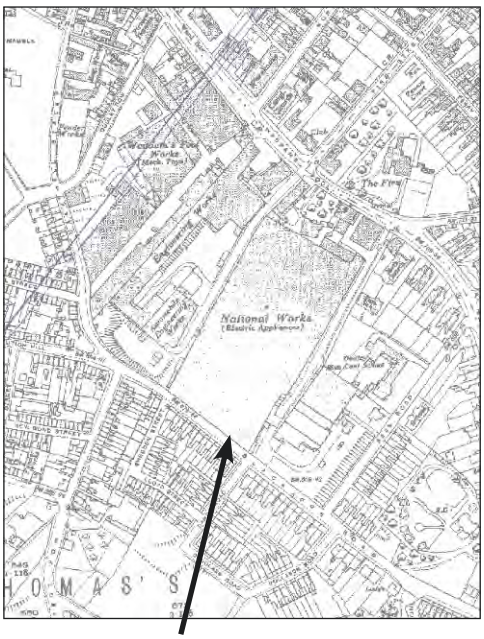
(1) 'History of the National Projectile Factory Birtley' TNA MUN 5/157

National Projectile Factory Dudley (42)	A Harper Sons & Bean, Hall Street, Waddams Pool, Dudley
Surviving structure: **Factory building** Status: Non-designated	NGR SO 94828 89890 NHRE No. 1574333

(P Boland)

Historic Site Plan

OS 1:2,500 map Staffordshire 1938



Factory

Modern Location Map

Surviving factory

Description/additional images

Construction of a projectile factory began in August 1915 on land acquired from Messrs A Harper Sons & Bean Ltd at Waddams Pool. There was no rail link due to the site being on a hill so road transport to Dudley station was relied upon.
The factory produced 18pdr, 60pdr, and 6in shells, as well as gun repair and aero engine work. Capacity reached in 1917 was 6,000 6in and 15,000 60pdr shrapnel shells produced per week. Latterly the 60pdr work was turned over to chemical shells. In October 1918 the factory had 5,767 employees of whom 44.4% were women. (1)

A Harper, Sons and Bean Ltd post-war sale catalogue survives at Dudley Archives.

Sources:

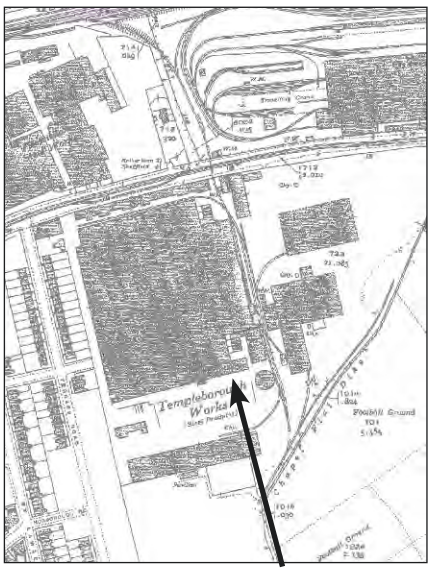
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 135-136

National Projectile Factory Sheffield (2. Templeborough) (53)	Templeborough Works, Sheffield Road, Rotherham
Surviving structure: **Factory buildings** Status: Non-designated	NGR SK40386 91305 NHRE No. 1574441

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Yorkshire 1934



Factory building

Modern Location Map

Surviving factory building

Description/additional images

Sheffield NPF was divided into two parts:
Tinsley Steel works; a forging shop was constructed on land rented from T Firth & Sons adjacent to their Tinsley steel works.
Templeborough; the main workshops were constructed at Templeborough on the Rotherham-Sheffield road.
Constructional work began in September 1915 and production began in January 1916. Shell forgings, 4.5in and 60pdr shell were produced. In October 1918 the workforce stood at 5,693 of whom 87.2% were women. (1)

Templeborough Works is depicted on the 1935 OS Map. This can be compared with an unnamed factory plan contained in *The Engineer* from 1916. (2) The factory depicted would appear to be Templeborough. Approximately half the former original structure appears to be standing.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 145-146

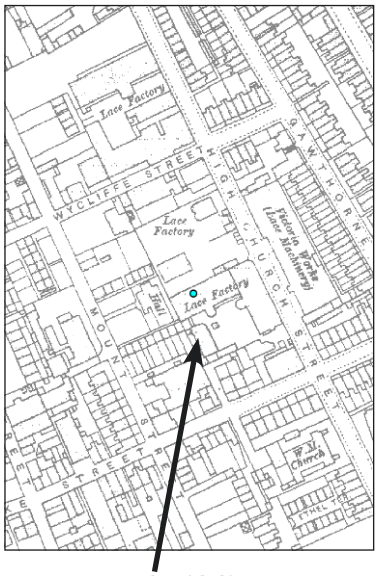
(2) A National Projectile Factory' Offprint from *The Engineer,* July 1916 TNA MUN5/157

National Ordnance Factory New Basford (179)	High Church Street, New Basford, Nottingham
Surviving structure: **Factory Building** Status: Non-designated	NGR SK 55979 42130 NHRE No. 1572889

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Nottinghamshire 1915



Factory buildings

Modern Location Map

Surviving factory building

Description/additional images

New Basford National Ordnance Factory was established after a lace factory was taken over under the Defence of the Realm Act in December 1917. It was set up to produce a new 37mm (1.5 pdr) gun required by the Air Force. This was initially developed by the Coventry Ordnance Works but manufacture on a large scale required additional premises, meaning the lace factory was taken over at New Basford, which occupied a floor space of 40,000 feet. It was strongly built but old, poorly lit and badly ventilated. Considerable alterations were required. The work of dismantling the equipment in the old factory began at the end of 1917, new plant was installed in February 1918, and manufacture began in May. The first two guns were not completed until mid-October so the factory had hardly got under way by the time the Armistice was signed in November. The chief difficulty had been a lack of skilled labour and a prolonged development period as a result. Nonetheless manufacture continued until 31 March 1919. At the end of 1918 the factory employed 400 people of whom 160 were women. (1)

A lace factory is depicted on wartime OS maps and this building appears to be still standing.

Sources:

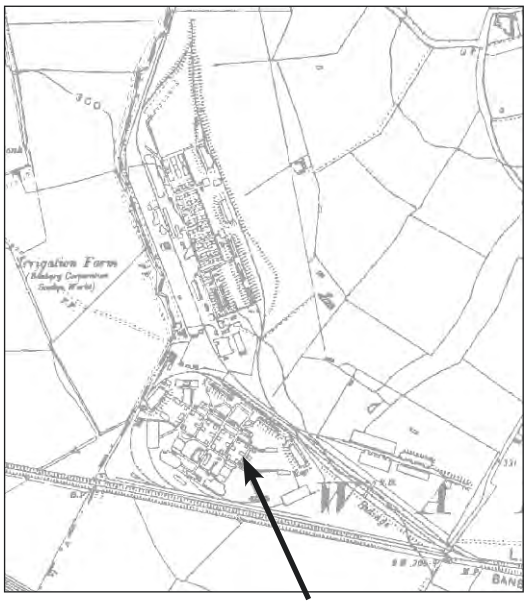
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 196

National Filling Factory Banbury No. 9 (83)	Warkworth, Nr Banbury, Oxfordshire
Surviving structure: **Earthworks** Status: Partial SAM	NGR SP 47714 40223 NHRE No. 1077570

(English Heritage)

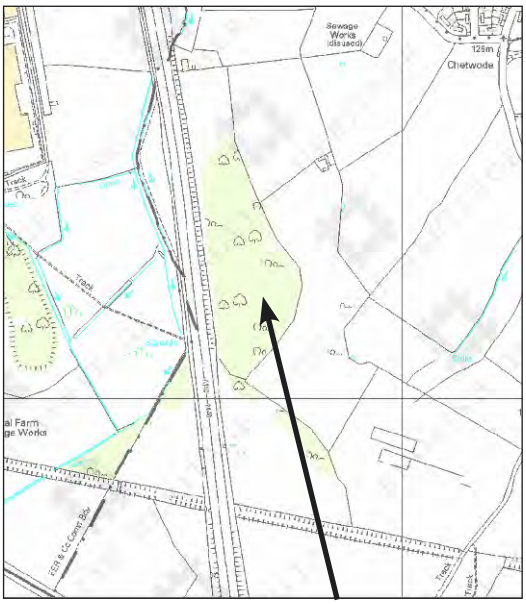
Historic Site Plan

OS 1:10,560 map Oxfordshire 1923



Factory buildings

Modern Location Map



Earthworks

Description/additional images

Construction was begun in January 1916 of a factory at Banbury to fill 6pdr to 9.2in shells with lyddite (picric acid). Capacity was initially for 100 tons of explosive per week but this was later doubled. H.2 Mines were also filled with ammonium perchlorate for the Admiralty. Some chemical filling was also carried out in 1918. In October 1918 the factory employed 1,463 people of whom 52.3% were women. (1)

A detailed account of the site and the processes carried out, with diagrams, survives at The National Archives. (2)

Earthwork bunds, concrete bases, and several railway embankments survive on the site. It is possible that at least one timber building from the site survives having been removed to Banbury for use as a store at a funeral undertaker. (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p. 159

(2) 'History of NFF No.9 Banbury and Description of the Filling Processes' TNA MUN5/155

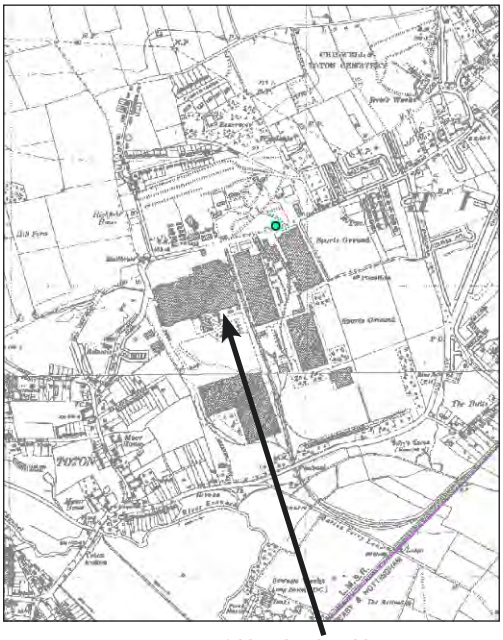
(3) Banbury Museum pers com.

National Filling Factory Chilwell No. 6 (48)	Chetwynd Road, Long Eaton, Nottingham
Surviving structure: **Factory Complex** Status: Non-designated	NGR SK 50703 35004 NHRE No. 1085832

(English Heritage AA96/3550)

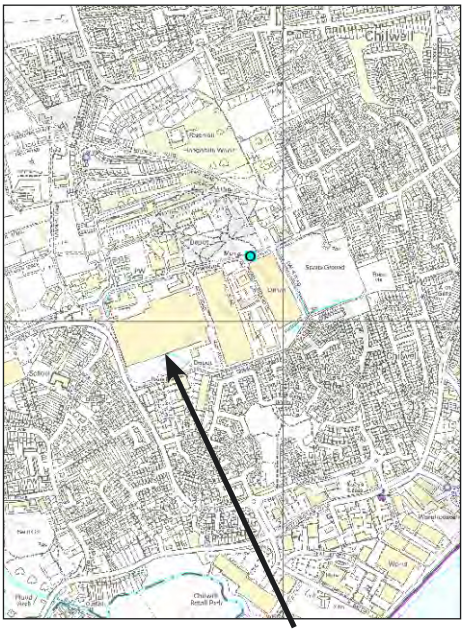
Historic Site Plan

OS 1:10,560 map Nottinghamshire 1939



Filled shell store

Modern Location Map



Filled shell store

Description/additional images

Nottingham was chosen as a good location for a filling factory as it was midway between the shell production centres in the north of England and the Channel ports. Lord Chetwynd acquired a site in Nottingham and construction was started in September 1915. The site was in two parts, north and south, separated by a road. To the north were the ammonium nitrate mill, TNT mill, amatol mixing house, canteens etc. To the south were the stores for explosives, filled and empty shell.
The factory filled over 50% of the 60-pounder and 15-inch shells used during the war; around 19,250,000 shells. In addition, it also filled naval mines and aerial bombs.
A serious explosion took place in July 1918 killing 134 workers. Reconstruction was not completed, although the factory continued production until the Armistice.
The number of workers in March 1917 7,452 of whom 1,730 were women. (1)

A published history of the site exists (2)

Also a file of photographs in The National Archives (3)

The site is now occupied by MoD, several First World War buildings survive, notably the large former Filled Shell Store.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 160-161

(2) Haslam, J, *The Chilwell Story, VC Factory and Ordnance Depot* (RAOC, Nottingham, 1982)

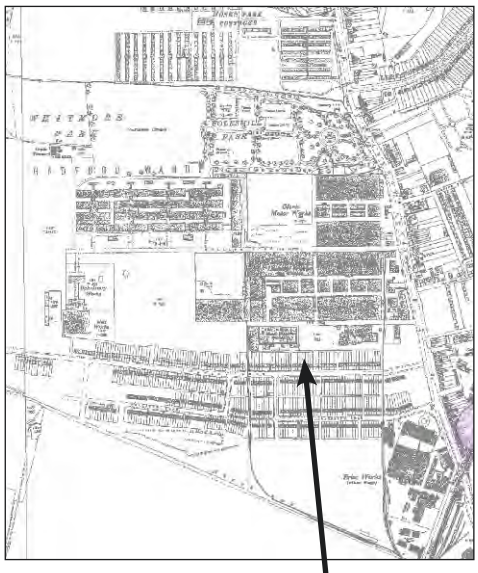
(3) TNA MUN5/157

National Filling Factory Coventry No. 10 or 21 (35)	Holbrook Lane, Whitmore Park, Coventry
Surviving structure: **Fuse Shops** Status: Non-designated	NGR SP 33300 82211 NHRE No. Not yet allocated

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Warwickshire 1937



Factory complex

Modern Location Map

Factory complex

Description/additional images

Construction began in September 1915 of a factory for filling No. 100 graze fuses adjacent to the existing White & Poppe engineering works at Whitmore Park. Output commenced in March 1916, and by September the factory was producing 150,000 No. 100 fuses per week as well as gaines and detonators. Poor assembly procedures led to a number of fuse failures in the winter of 1916-17. After an enquiry procedures were improved and the factory number was changed to No. 21 to prevent mistrust of the fuses by frontline troops.
In March 1917 the labour force numbered 3,864 of whom 90.3% were women. (1)
Most of the fuse factory is demolished but parts of the No 80 fuse shops on the north-west side survive.

Britain From Above image showing site (2)

A typescript history of the site and an album of photographs of construction survive in The National Archives. (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 161-163

(2) http://www.britainfromabove.org.uk/image/epw055120

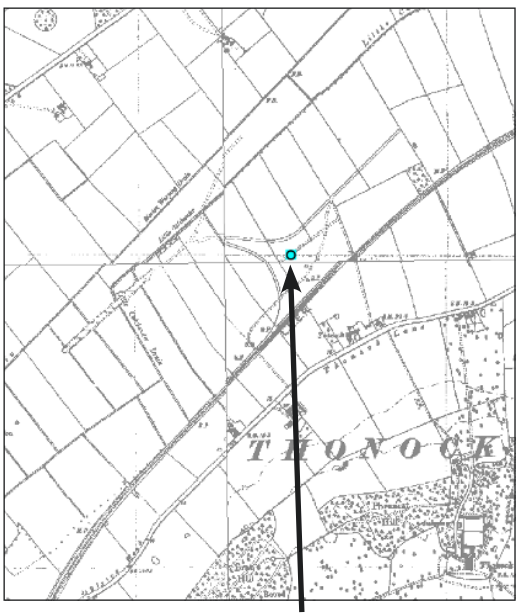
(3) 'Report of the Coventry National Filling Factory 1915-1918' TNA MUN5/155, and Photo Album TNA MUN5/157

National Filling Factory Gainsborough No. 22 (178)	North of Thonock Lane Farm (A159), Gainsborough, Lincolnshire
Surviving structure: **Possible earthworks** Status: Non-designated	NGR SK 82488 93036 NHRE No. 1077819

(Margaret Arbon/Gainsborough and District Heritage Association)

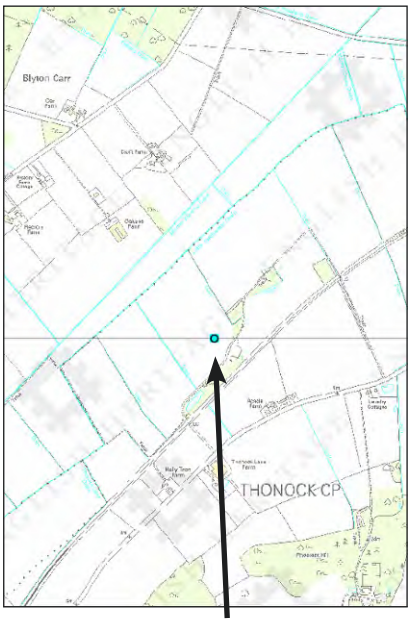
Historic Site Plan

OS 1:10,560 map Lincolnshire 1948



Site of works

Modern Location Map



Site of works

Description/additional images

Production started at Gainsborough in February 1918 for the filling of naval mine sinkers. Maximum output was 70 sinkers in 24 hours but more typically 200 per week. The number of employees in October 1918 was 322, of whom 53.4% were women. (1)

1948 map shows redundant sidings to the north of the railway line, also Google Earth shows possible bunded structures and irregular tree growth.
A site visit and photography carried out in 1996 identified remains of concrete building platforms, earth bunds, and the hard standing for the former rail sidings. (2)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.163

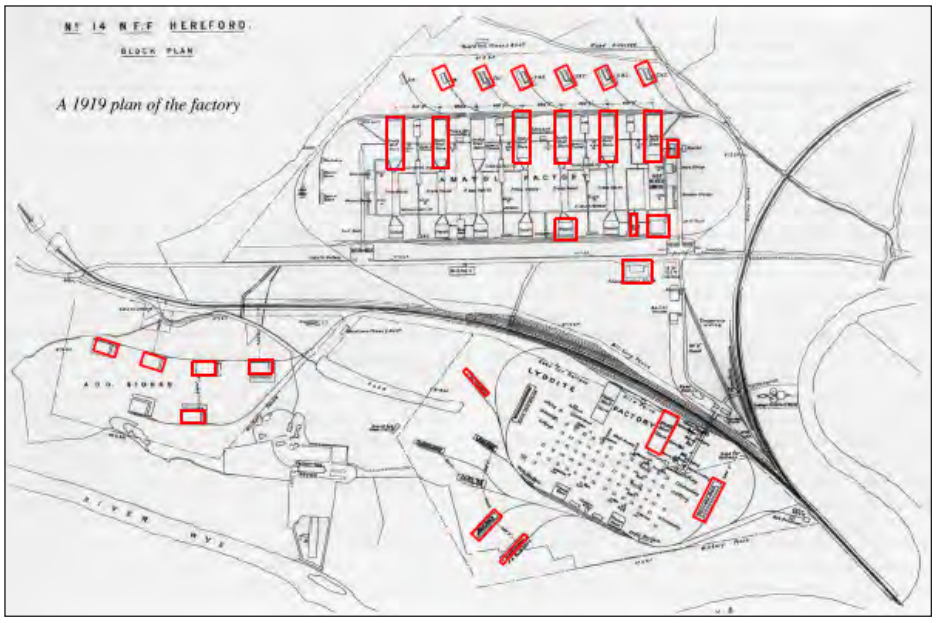
(2) English Heritage (AF1088584)

National Filling Factory Hereford No. 14 (108)	Rotherwas Industrial Estate, Hereford, Herefordshire
Surviving structures: **c. 30 surviving structures** Status: One bldg Listed at Gr II	NGR SO 52850 38551 NHRE No. 1083252

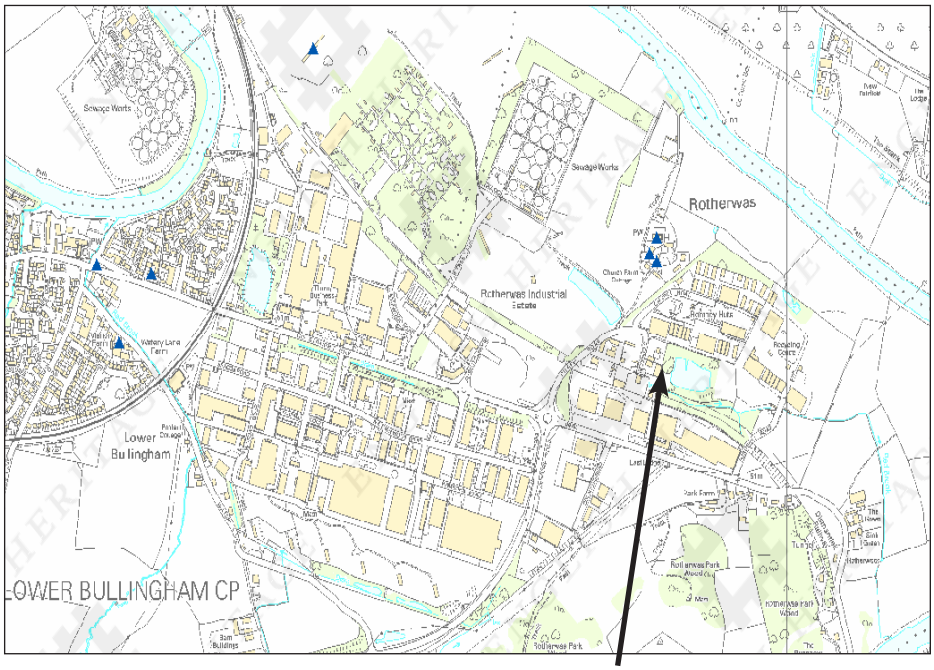
Empty-Shell Store (M Bellamy)

Historic Site Plan

1919 site plan (2) showing surviving structures (inverted to show N at top)



Modern Location Map



Surviving structures

Description/additional images

Construction began in July 1916 for an additional filling factory to allow for the possible loss of the plants at Chilwell or Morecambe. Output began in November 1916 producing up to 100,000 shells per week (18pdr to 9.2in). Charging of gas shells with HS was also undertaken. Staff in October 1918 totalled 5,758 of whom 66.8% were women. (1)

The site was rebuilt in 1930s but some First World War buildings survive. Comparison of description in Edmonds (2) with modern air photography suggests as many as 30 First World War structures survive in whole or in part. These include empty shell stores, explosives stores and magazines, and the administration block.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.167-168

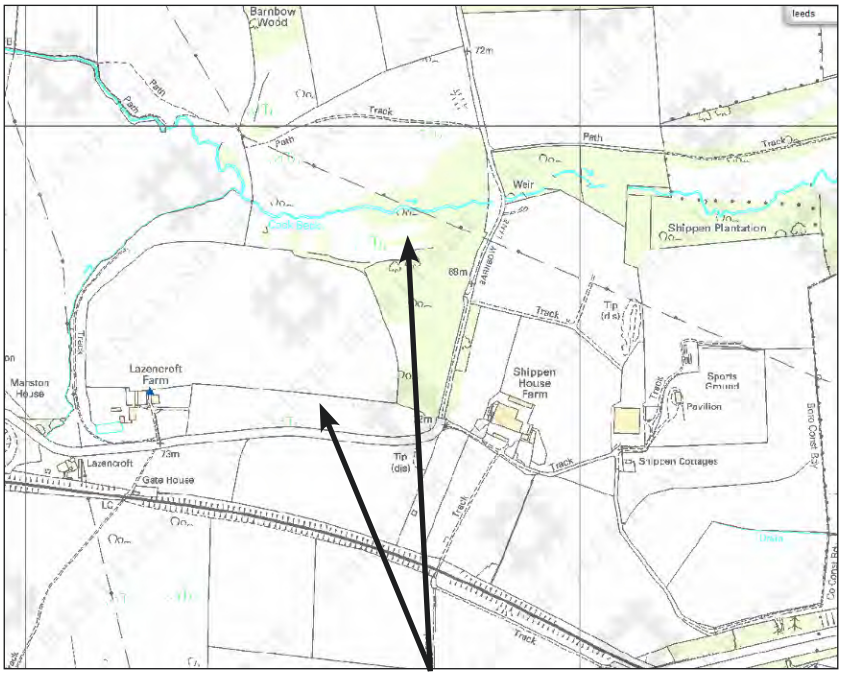
(2) Edmonds, J, *The History of Rotherwas Munitions Factory*, (Hereford, 2004)

(3) Typescript history, TNA MUN5 154

National Filling Factory Leeds No. 1 (63)	Barnbow Common, Leeds, Yorkshire
Surviving structure: **Earthworks, bldg footings** Status: Under consideration for Scheduling	NGR SE 34663 31993 NHRE No. 1386780 1067543

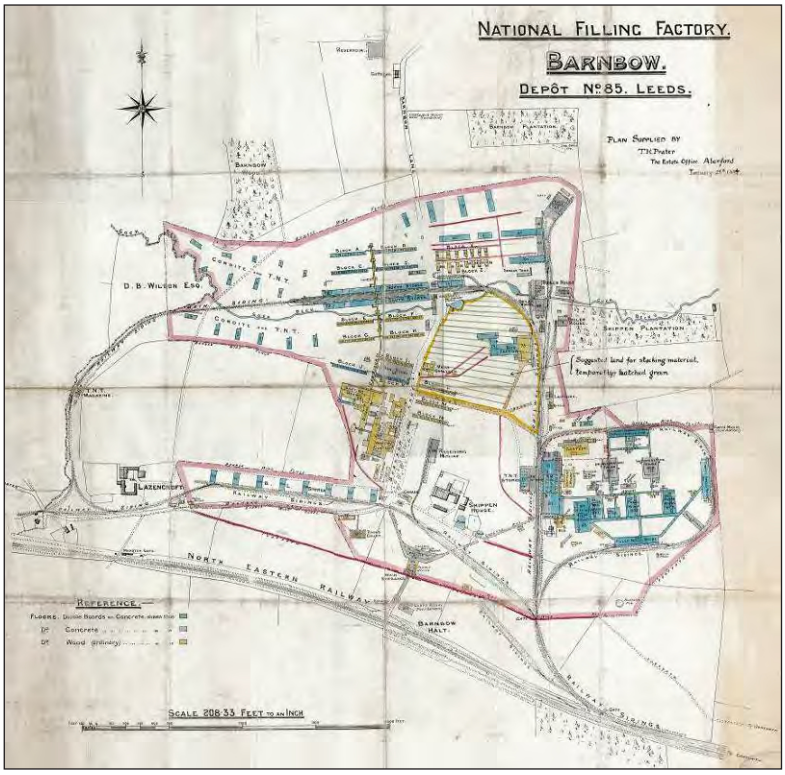
(W Cocroft)

Modern Location Map



Earthworks

Description/additional images



1924 Site plan (WYAS)

Barnbow was the first of the 18pdr QF filling and assembly plants to be initiated by the Ministry of Munitions in summer 1915. The first shells were filled in April 1916. By August 1918 the plant produced 50,000 shells weekly. The workforce peaked in March 1917 at 13,315 employees, of whom 12,150 were women. (1)(2)

Although no standing buildings remain, a number of earthworks, floor slabs and building footings remain, and the site is under consideration for scheduling. (WYAS Report, unpublished.)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.168-169

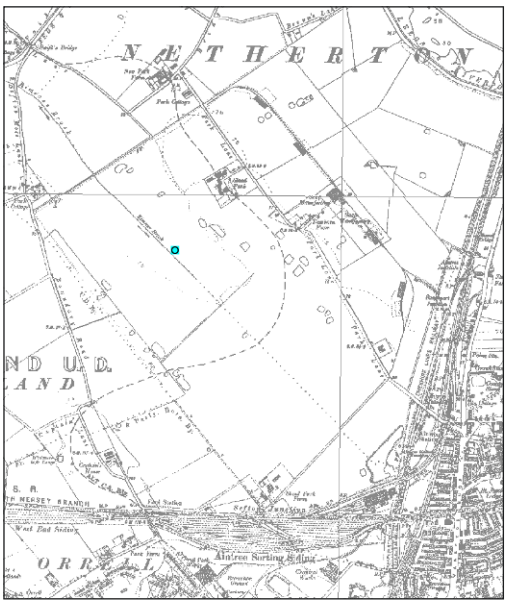
(2) Printed history TNA MUN5/155 and photos TNA MUN5/157

National Filling Factory Liverpool No. 2 (34)	Dunnings Bridge Road, Aintree, Liverpool
Surviving structure: **Crop marks** Status: Non-designated	NGR SJ 35810 98391 NHRE No. 1077538 1077551

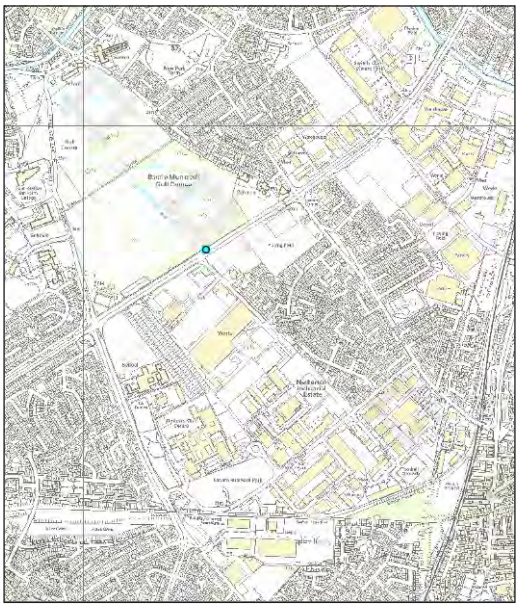
No current image of this structure is available.

Historic Site Plan

OS 1:10,560 map Lancashire 1928



Modern Location Map



Description/additional images

Construction on a shell filling factory was begun in October 1915, partly to complete 18pdr rounds imported from the USA via Liverpool. The site ultimately filled shells up to 8in, as well as filling and assembling components. A total of 17,340,100 shells of all types were completed during the war, as well as bagged charges, fuses etc. In August 1918 there were 8,599 employees of whom 87.1% were women. (1)

No standing buildings survive from the factory but rail lines appear as crop marks on Bootle golf course.

2nd NRHE no refers to extension of factory for Amatol in 1916.

A typescript history with output charts and site plans survives in The National Archives (2) along with a file of construction photographs. (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.169-170

(2) 'History of No. 2 Filling Factory Aintree Liverpool' TNA MUN5/155

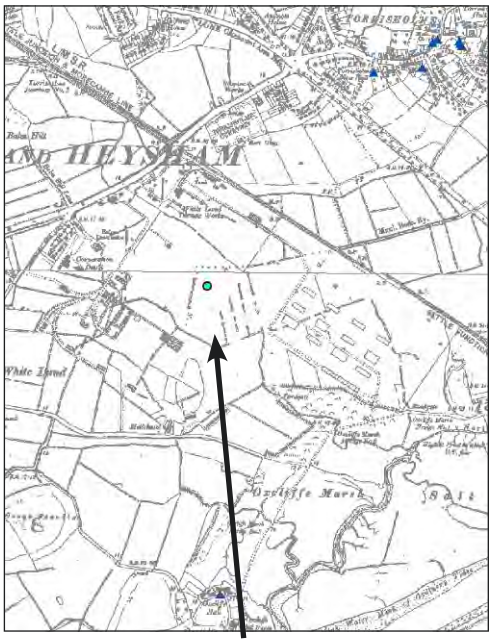
(3) 'Photographs of No.2 Filling Factory Liverpool December 1915' TNA MUN5/157

National Filling Factory Morecambe No. 13 (50)	Northgate, White Lund Trading Estate, Morecambe, Lancashire
Surviving structure: **Power House** Status: Non-designated	NGR SD 44946 62975 NHRE No. Not yet allocated

The power house in the 1990s (W Cocroft)

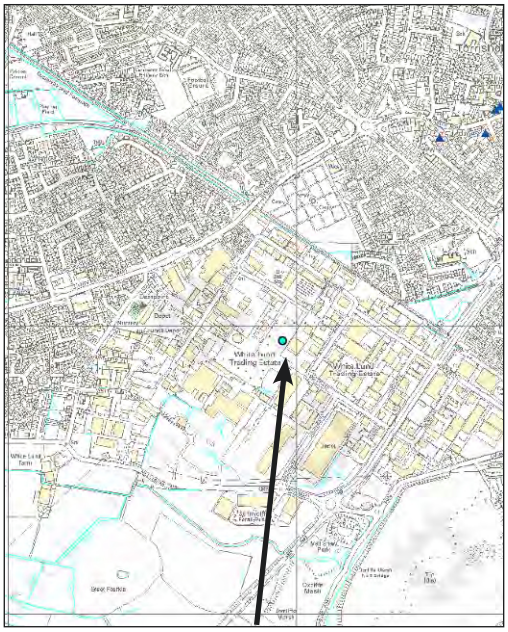
Historic Site Plan

OS 1:10,560 map Lancashire 1931



Factory site

Modern Location Map

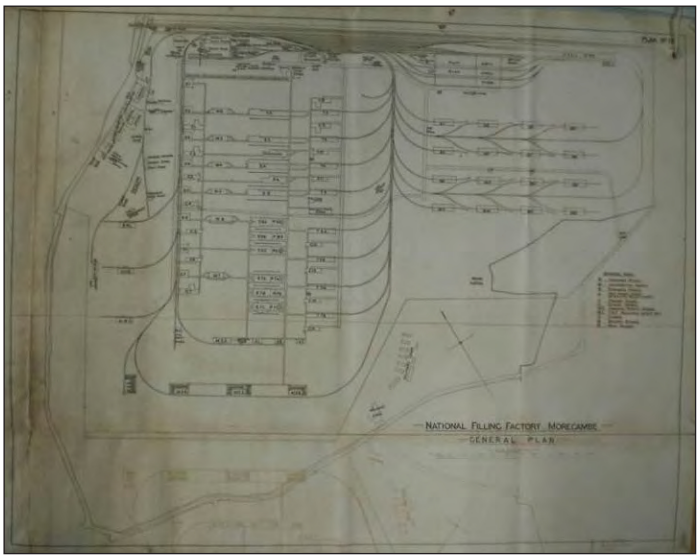


Factory site with some surviving buildings

Description/additional images

Construction of a filling factory at Morecambe was undertaken in November 1915 in cooperation with Vickers. Output began in July 1916. Shells filled included 60pdr, 6in, 8in, 9.2in, and 12in shell. The factory was almost entirely destroyed by explosions and fire on 3 October 1917. At peak in September 1917 there were 4621 employees of whom 64.4% were women. (1)

The extent of the site is apparent from plans in The National Archives. The area is now an industrial estate, one building on north edge may be standing (the electrical power plant).



Plan from TNA MUN5/154

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.170-171

(2) 'History of Morecambe National Filling Factory ' TNA MUN5/154

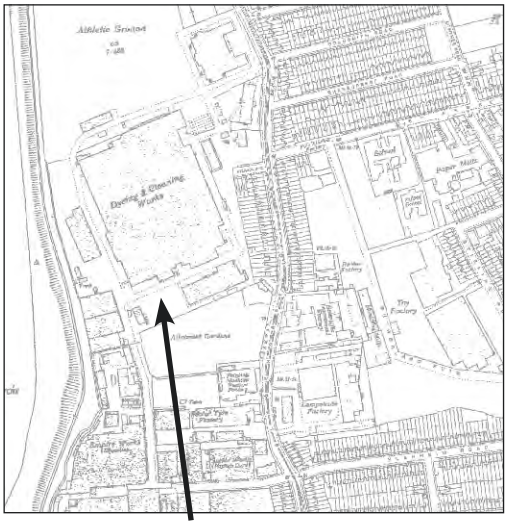
(3) 'Photographs Morecambe National Filling Factory December 1915' TNA MUN5/157

Trench Warfare Filling Factory (Chemical) Walthamstow (107)	Uplands Business Park, Black Horse Lane, Higham Hill, Walthamstow
Surviving structure: **Factory Buildings** Status: Non-designated	NGR NHRE No. 1575523 1075974

No current image of this structure is available.

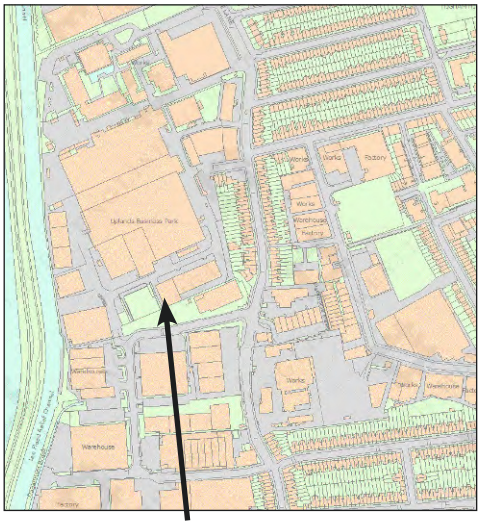
Historic Site Plan

OS 1:2,500 map Essex 1931



Factory building

Modern Location Map



Surviving buildings

Description/additional images

H M Factory Walthamstow was constructed on waste ground adjacent to the Messrs Baird & Tatlock scientific instrument works on Black Horse Lane, utilising the existing glass working facilities. Charging of lachrymatory grenades and shells was carried out. Workers averaged around 250, and were 'typically' women. (1)
A report on the specialist filling activities along with photos, but no site plans, survives in The National Archives. (2)

A number of buildings adjacent to the Baird & Tatlock works survive, although not the original factory and offices. These include at least one with a distinctive north light roof with tie beams at ridge level, a design feature common with other filling factory buildings.

Britain From Above image showing site (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.184

(2) 'Report on the work carried out at H.M. Factory Walthamstow during the War (1914-1918)' TNA MUN5/368

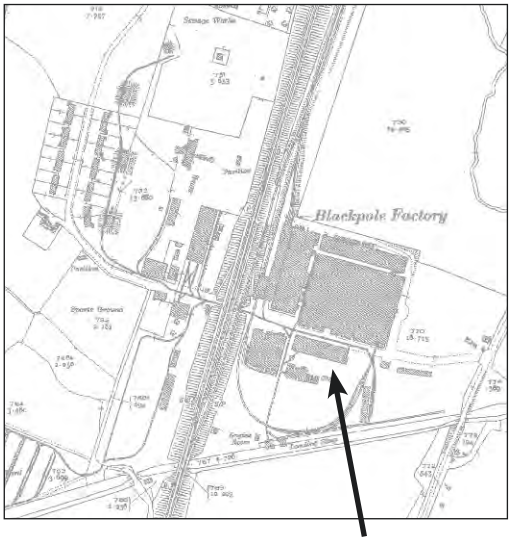
(3) http://www.britainfromabove.org.uk/image/epw017338

Government Cartridge Factory No. 3 Blackpole (101)	Blackpole East, Blackpole Road, Worcester, Worcestershire
Surviving structure: **Factory** Status Non-designated	NGR SO 86622 57775 NHRE No. 1574528

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Worcester 1928



Factory building

Modern Location Map

Surviving factory

Description/additional images

A Government Cartridge Factory was established at Blackpole, Worcestershire, in March 1916. It was one of four such factories and was therefore referred to as 'Government Cartridge Factory No.3'. The others were at Blackheath, Edmonton (Angel Road) and Woolwich.
The site selected at Blackpole covered 67.25 acres. The factory was managed by the King's Norton Metal Company. The buildings were completed by February 1917. Initially the factory produced 7.62mm ammunition for the Russian Army but latterly was switched to .303 inch production. By August 1918 a total of 192 million .303 inch rounds had been produced. Initially the men in the skilled tool room were opposed to utilising female labour but eventually women and boys formed a significant part of the labour force. In October 1918 there were 3,235 employees of whom 76% were women. (1)
After the war the factory was taken over by Cadbury's and converted to producing chocolate bars. Much of the First World War factory still stands. (2)

Britain From Above image showing site in 1930 (3)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.189

(2) http://www.miac.org.uk/cadburyblackpole.html (accessed 29/9/2014)

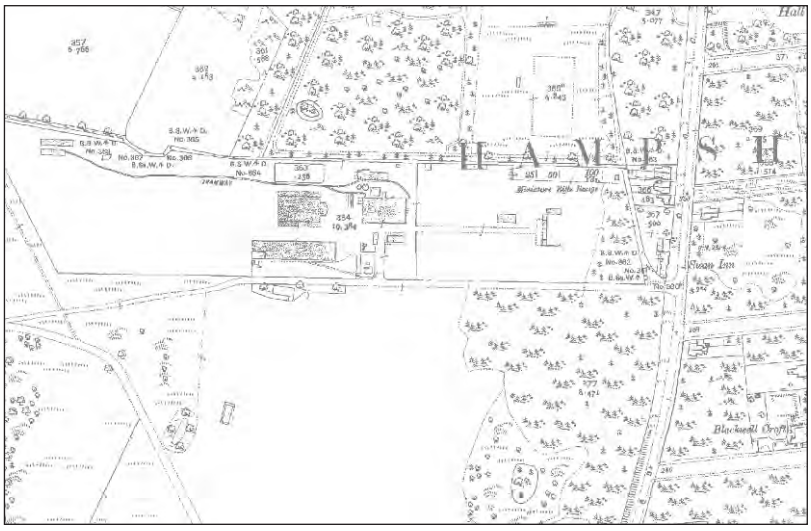
(3) http://www.britainfromabove.org.uk/image/epw034590 (accessed 29/9/2014)

Royal Aircraft Factory Farnborough (4)	Farnborough Road, Farnborough, Hampshire
Surviving structure: **Office building and hangars** Status: Listed Grade II and II*	NGR SU 86737 54543 NHRE No. 1381516

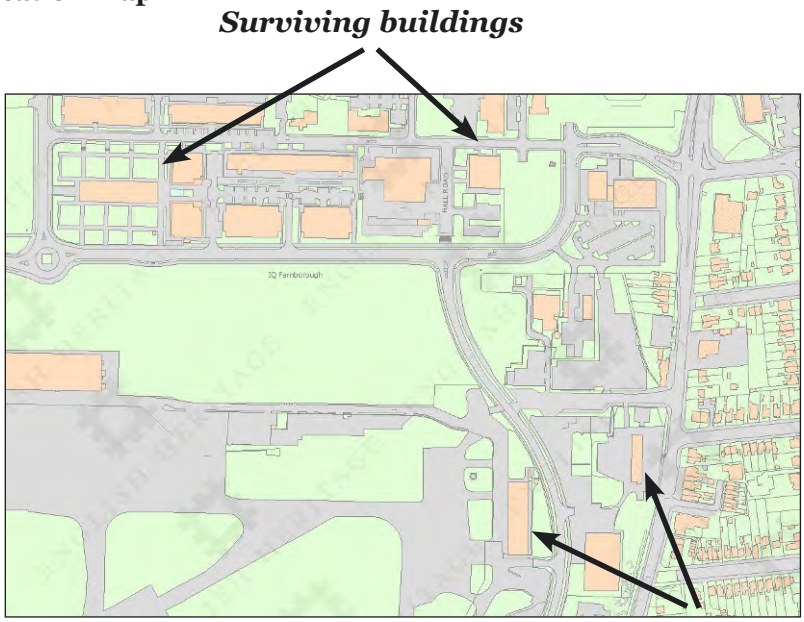
Black Sheds (English Heritage BB98/26746)

Historic Site Plan

OS 1:2,500 map Hampshire 1911



Modern Location Map



Description/additional images

The Royal Aircraft Factory was established as a balloon factory in 1905. It switched to heavier-than-air craft in 1913 when the Navy took over airship manufacture. It continued as the principal government research and testing site throughout the Great War and after, changing its name to the Royal Aircraft Establishment in 1918 to avoid confusion with the newly formed Royal Air Force.(1)

Four Great War period buildings survive on the site:

- 1393074- A former airship hangar built in 1912, listed Grade II
- 1390502- A wind tunnel built in 1916, isted Grade II
- 1339706- Headquarters of No 1 (Airship) Company of the Air Battalion of the Royal Engineers, built in 1911, listed Grade II*
- 1339694- A corrugated iron hangar known as the 'Black sheds' constructed in 1912, listed Grade II

Sources:

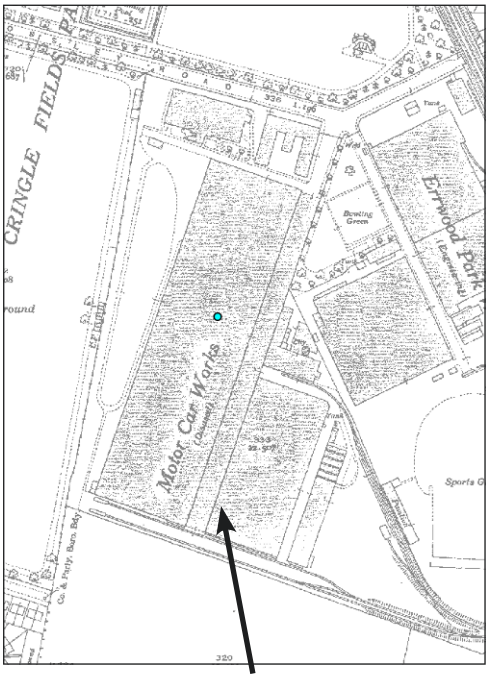
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp. 38-39

National Aircraft Factory No. 2 Heaton Chapel (165)	Crossley Road, Heaton Chapel, Manchester
Surviving structure: **Factory building** Status: Non-designated	NGR SJ 87448 92964 NHRE No. 1574577

No current image of this structure is available.

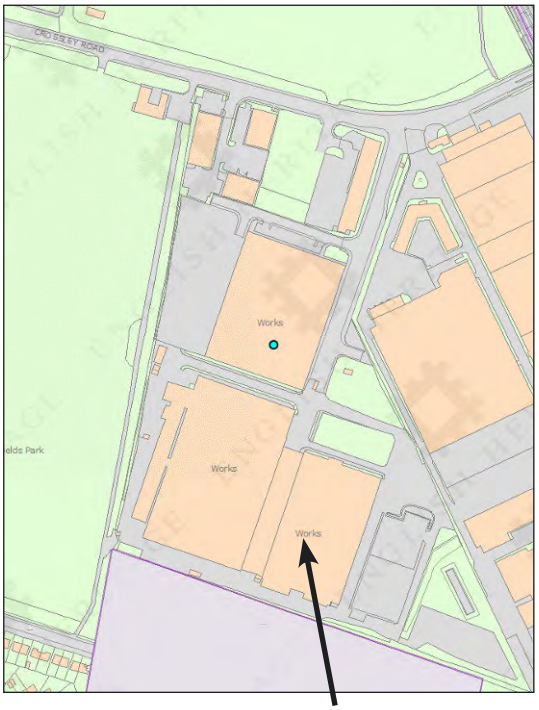
Historic Site Plan

OS 1:2,500 map Lancashire 1934



Factory building

Modern Location Map



Surviving buildings

Description/additional images

In summer 1917 it was decided to expand the aircraft manufacturing programme and create three large National Aircraft Factories. These were at Aintree (Liverpool) Heaton Chapel (Manchester) and Waddon (Croydon). A further site at Richmond was ultimately not nationalised.
The site at Heaton Chapel was managed by Crossley Motors Ltd with the aim of producing 40 machines per week. DH 9 and DH10 aircraft were produced but the 40 per week target was never reached. The site employed 2,540 employees in September 1918 of whom 37.5% were women. (1)
The former Crossley works (later Fairey aircraft) is shown on post-First World War OS maps and parts appear to be still extant. A new plant was erected in 1917 and it is likely that these are the buildings to the west of the site, at an angle to the earlier works. One surviving section has external beams connecting the north-light roofs at the apex, a feature seen at other First World War factory sites.

Britain From Above image showing site 1949 (2)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.197-204

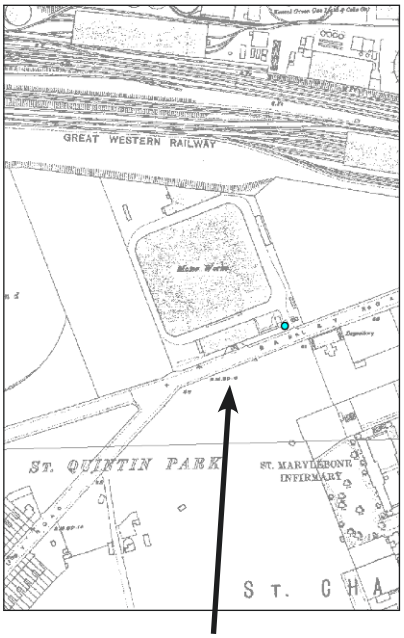
(2) http://www.britainfromabove.org.uk/image/eaw024179 (accessed 30/06/2014)

National Aero-Engine Factory Ladbroke Grove (193)	Ladbroke Hall, Barlby Road, Ladbroke Grove, London
Surviving structure: **Office Building** Status: Listed Bldg Grade II	NGR TQ 23577 81989 NHRE No. 1220415

(English Heritage 2K/15818)

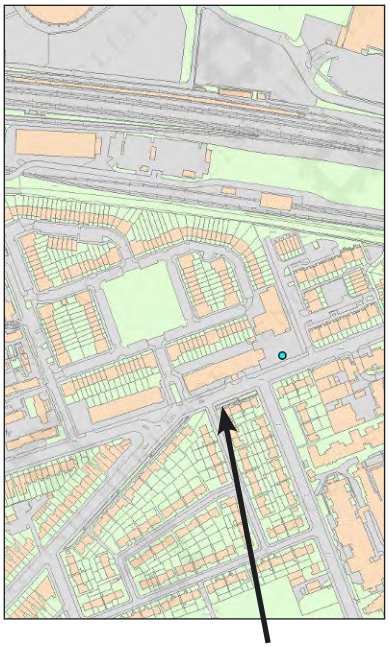
Historic Site Plan

OS 1:2,500 map London 1915



Office building

Modern Location Map



Surviving office building

Description/additional images

In 1917 there was increased demand for Rolls Royce aero-engine repairs so the Clement Talbot works at Ladbroke Grove was assigned this work. Friction over repairing a rival firm's product led to the nationalisation of the plant in January 1918, after which repair of Rolls Royce aero engines was carried out and spares for Talbot motor cars were produced. The factory employed 1,994 people in November 1918, of whom 18.6% were women. (1)

Main factory buildings have been demolished but administration building survives and is listed at Gr II.

Sources:

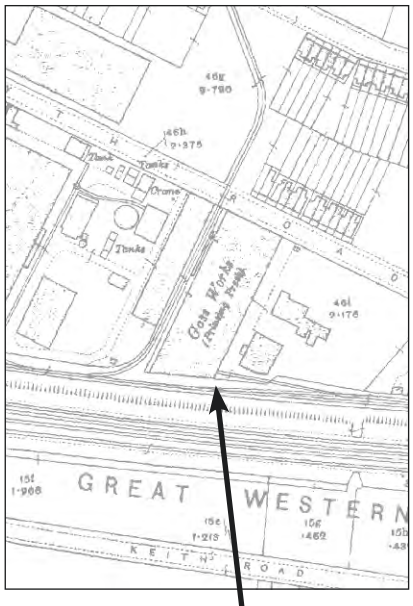
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.205-207

National Aero-Engine Factory Hayes (166)	Former Goss Works, Blyth Road, Hayes, Middlesex
Surviving structure: **Factory building** Status: Non-designated	NGR TQ 09418 79498 NHRE No. 1574548

No current image of this structure is available.

Historic Site Plan

OS 1:25,000 map Middlesex 1914



Factory

Modern Location Map

Possible survival

Description/additional images

This factory was established in the former Goss printing works on Blyth Road Hayes for the supply of aero-engine parts. The factory was initially administered by Mitchell, Shaw & Co. but was taken over by the Ministry in October 1917. The factory became known for the quality of its output, partly as a result of the higher than average wages paid to staff. The number of employees in October 1918 was 761, of whom 28.5% were women. (1)

This factory is marked on the 1914 OS map and appears to be still extant. The 1934 map shows the factory extended to the east to its current extent but it is not known if this represents wartime construction.

Sources:

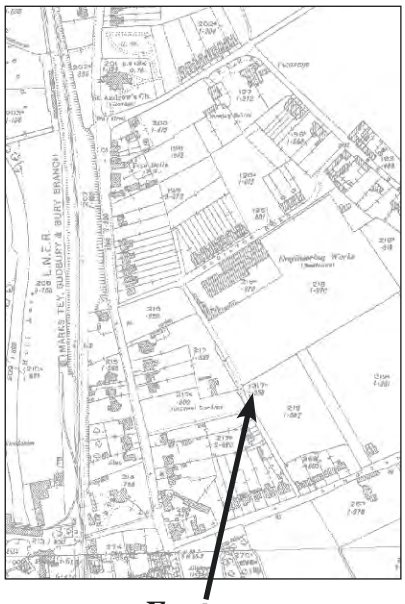
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.207-208

National Radiator Factory Sudbury (196)	Radiator Road, Sudbury, Suffolk
Surviving structure: **Factory building** Status: Non-designated	NGR TL 88454 40221 NHRE No. Not yet allocated

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Suffolk 1926



Modern Location Map

Description/additional images

In the summer of 1917 demand for radiators for aircraft became acute, and the existing industry was strangled by union resistance to dilution and mass production. On 1 January 1918 the Motor Radiator Manufacturing Co. in Greet in Birmingham was taken over by the Ministry. Following this the branch factory at Sudbury was also taken over and run as a subsidiary of the Greet plant. The Sudbury works was used in particular for the repair of radiators for SE5 scout aircraft. The factory had a capacity for 130-150 employees but was never fully staffed, having typically around 50. (1)

The Motor Radiator Manufacturing Co. Later became Serck Radiator Co. located on Radiator Road, depicted on 1923 OS map and marked as a radiator works. The Company later moved 1935 to Meadow Lane, Sudbury. (2)

One possible factory building survives adjacent to south side of Radiator Road.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.211-212

(2) http://www.gracesguide.co.uk/Serck_Radiators (accessed 06/10/2014)

Anti-Gas Factory Holloway (217)	Batavia Mills, Elthorne Road, Holloway, London
Surviving structure: **Mill building** Status: Non-designated	NGR TQ 29591 86804 NHRE No. 1574523

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map London 1935

Mill building

Modern Location Map

Mill building

Description/additional images

In August 1918 the Ministry opened new National Factories for the manufacture of 'Green Band' respirators at Batavia Mill and Holloway Mills, Holloway. By the time of the Armistice these plants had produced 55,140 respirators as well as a large number of spare parts. (1)

Batavia Mills on Elthorne Road is marked on the 1935 OS map and is still extant.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.229

Anti-Gas Factory Holloway (218)	Holloway Mills, Elthorne Road, Holloway, London
Surviving structure: **Mill building** Status: Non-designated	NGR TQ 29618 86898 NHRE No. 1574525

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map London 1935

Mill building

Modern Location Map

Mill building

Description/additional images

In August 1918 the Ministry opened new National Factories for the manufacture of 'Green Band' respirators at Batavia Mill and Holloway Mills, Holloway. By the time of the Armistice these plants had produced 55,140 respirators as well as a large number of spare parts. (1)

Holloway Mills on Elthorne Road is marked on the 1935 OS map and is still extant.

Sources:

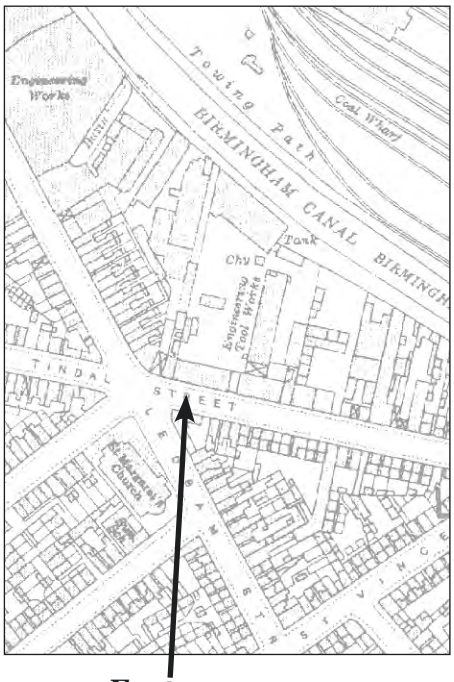
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.229

National Gauge Factory Birmingham (66)	Victoria Works, Great Tindal Street, Birmingham
Surviving structure: **Factory building** Status: Non-designated	NGR SP05372 86842 NHRE No. 1573411

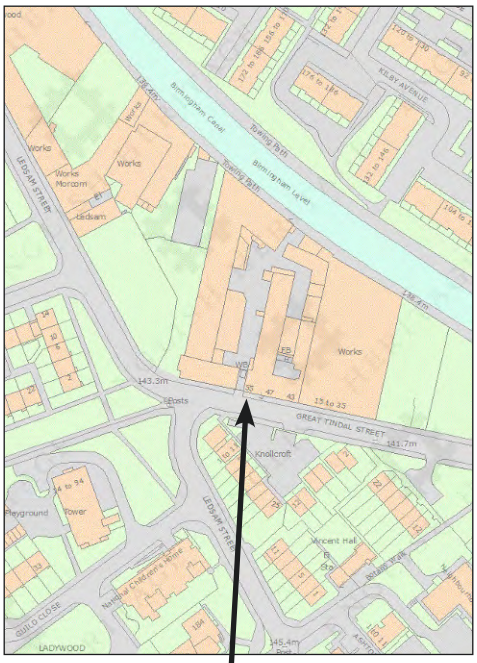
No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Warwickshire 1918



Modern Location Map



Description/additional images

A requirement for standardised tools and gauges was identified in 1915, but it was not possible to establish a single central factory. Instead factories were acquired at Woolwich, Birmingham, and Croydon. These were followed by the Wolsey Motor Co. in Pimlico, and Newall Engineering Co. in Walthamstow, taken over in 1917 and 1918 respectively. The main output of the Birmingham factory was small tools, taps and dies, and the plant was taken over from Chatwin & Co., an existing maker.

Chatwin Ltd formerly occupied Victoria Works on Great Tindal Street, (2) and the tool factory is labelled on wartime OS maps. These buildings still stand.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.214-216

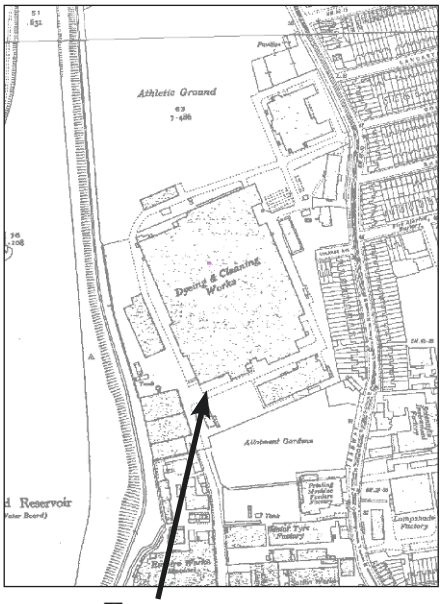
(2) http://www.gracesguide.co.uk/Thomas_Chatwin (accessed 6/10/2014)

National Gauge Factory Walthamstow (202)	Uplands Business Park, Black Horse Lane, Wathamstow, London
Surviving structure: **Factory building** Status: Non-designated	NGR TQ 35732 90072 NHRE No. Not yet allocated

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Essex 1935



Factory

Modern Location Map

Factory

Description/additional images

A requirement for standardised tools and gauges was identified in 1915, but it was not possible to establish a single central factory. Instead factories were acquired at Woolwich, Birmingham, and Croydon. These were followed by the Wolsey Motor Co. in Pimlico, and Newall Engineering Co in Walthamstow, taken over in 1917 and 1918 respectively. Newall Engineering is listed in Black Horse Lane, Walthamstow. (1)

The Newall Engineering Co. factory is known to have been sold to a dyeing and cleaning company in 1928. A large dyeing and cleaning works appears on the OS map of 1936. This may be the location of Newall Gauge Factory. (2)

The extant factory may have 1914-1918 elements. This site appears to be immediately adjacent to the Walthamstow Trench Warfare Filling Factory (TWFF) also on Black Horse Lane.

The location is currently in NRHE as the Walthamstow NEF 1575523.

Sources:

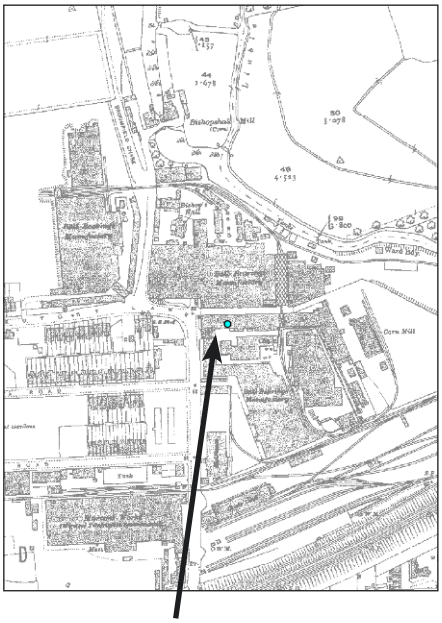
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II pp.214-216

(2) http://en.wikipedia.org/wiki/Peter_Hooker (accessed 6/10/2014)

National Ball Bearing Factory Chelmsford (156)	Globe House, Rectory Lane, Chelmsford, Essex
Surviving structure: **Factory building** Status: Non-designated	NGR TL 7095 07545 NHRE No. 1574651

(English Heritage AA99/01800)

Historic Site Plan
OS 1:2,500 map Essex



Modern Location Map

Description/additional images

In September 1917 the Hoffman Manufacturing Co. which was producing ball-bearings on a large scale became a National Factory. The company was bought out as their existing owners were reluctant to expand to cope with the additional demands for product from the aircraft industry. 230,000 ball-bearings a month were being produced by October 1918. (1)

The 1921 OS map (1:2500) indicates that this factory was originally a huge complex comprising many buildings situated just to the north of Marconi Works. However the only building that remains extant is a long range that now comprises Globe House, Durrant Court and Ashby House of Anglia Ruskin University.

Britain From Above image showing site (2)

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.215

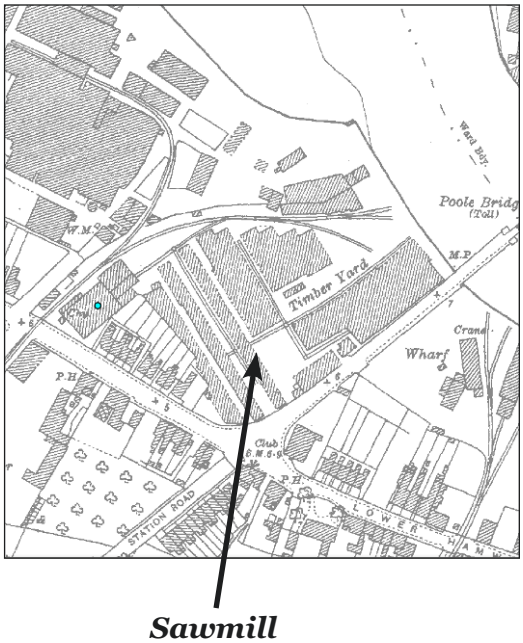
(2) http://www.britainfromabove.org.uk/image/epw009600 (accessed 6/10/2014)

National Sawmill Poole (172)	Hamworthy Wharf, Poole, Dorset
Surviving structure: **Sawmill** Status: Non-designated	NGR SZ 00389 90287 NHRE No. 1573383

No current image of this structure is available.

Historic Site Plan

OS 1:2,500 map Dorset 1925



Sawmill

Modern Location Map

Sawmill

Description/additional images

A series of sawmills was taken over starting in September 1917 to provide boarding for 'miscellaneous packages' and boxes. These plants were mostly operated by their original owners with a ministry representative on site, and reverted to their owners after the Armistice. The sawmill in Poole was operated by Messrs J T Sydenham & Co. (1)

A timber yard is shown on the 1890, 1902 and 1925 OS Maps just to the north of Hamworthy Railway Station on Hamworthy Road. These premises continue to be in the hands of Sydenham & Co. and are likely to be the same premises as used in 1917-18, part of which may include the original buildings. (2)

In particular, the sawmill building in the western corner of the site seems to share a footprint with a wartime structure.

Sources:

(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (HMSO London) Vol. VIII Pt II p.220

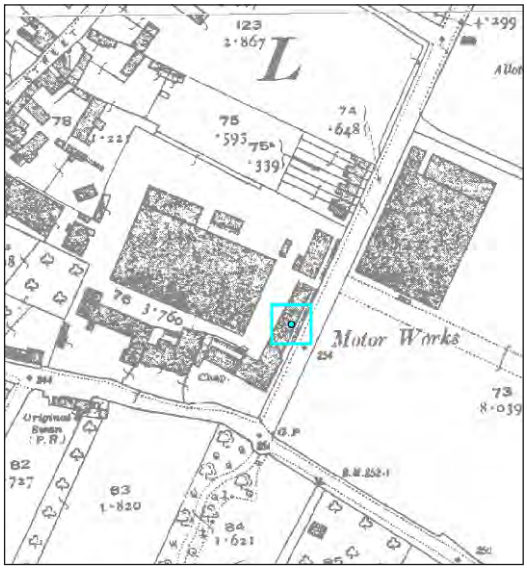
(2) http://www.sydenhams.co.uk/branches/poole.aspx (accessed 6/10/2014)

Mine Sinker Assembly Station Cowley (133)	W R M Motors Ltd, Hollow Way, Cowley, Oxfordshire
Surviving structure: **Car Factory** Status: Listed Bldg Grade II	NGR SP 54707 04316 NHRE No. 602472

(English Heritage BB026366)

Historic Site Plan

OS 1:2,500 map Oxfordshire 1921



Modern Location Map

Description/additional images

Early in 1917 the Trench Warfare Dept. undertook to meet demands from the Admiralty for mine sinkers. Parts were manufactured on a group system and assembled at a central plant at the W R M Motor Co. in Cowley. A large empty building was taken over but parts of the main works were also utilised. By October 1917, 750 sinkers a week were being assembled. In January 1918 there were 411 workers of whom 36% were women. (1)

The original building used as the Morris car factory still stands and is listed Gr II. The 1925 OS shows an adjacent building matching the dimensions for the mine factory given in the Official *History*, but this is now demolished.

Sources:

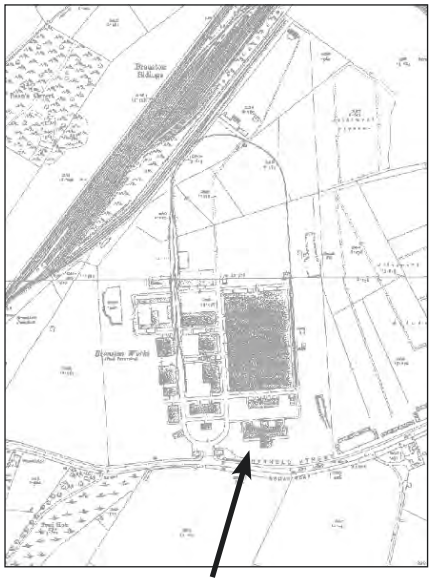
(1) Ministry of Munitions, 1920-23, *History of the Ministry of Munitions* (H.M.S.O. London) Vol. VIII Pt II p.220

National Machine Gun Factory Burton on Trent (163)	Burton Road, Branston, Staffordshire
Surviving structure: Factory and office buildings Status: Listed Bldg Grade II	NGR SK 23351 21441 NHRE No. 922427

(W Cocroft)

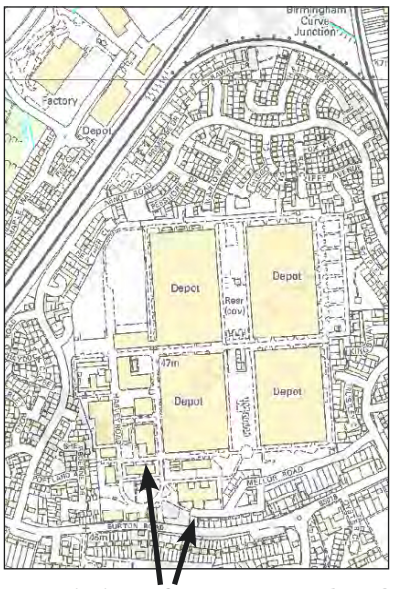
Historic Site Plan

From OS 1:2,500 map Derbyshire 1923



Factory and office buildings

Modern Location Map



Surviving factory and office buildings

Description/additional images

In the autumn of 1917 it was decided by a specially convened sub-committee of the Munitions Council that machine gun production was inadequate for the probable requirements of 1918 and a new factory would be required. A site was chosen at Burton-on-Trent. The aim was to produce 400 machine guns per week but factory construction was still underway at the Armistice. Brick and steel-framed buildings were erected. Consideration was briefly given to keeping the site for MG repair or for future manufacture but this proved impractical and the site was sold off. (1)

The factory on Burton Road, Branston, was acquired in 1921 by Crosse & Blackwell and subsequently became the Branston pickle factory. However pickle production was moved and the site was sold again in 1927. (2)

Three buildings are extant and Listed Grade II, including the offices, canteen, and pump-house.

Sources:

(1) Ministry of Munitions, 1920-23, History of the Ministry of Munitions (HMSO London) Vol. VIII Pt II p.222

(2) http://www.burton-on-trent.org.uk/category/surviving/branston-depot/branston-pickle (accessed 6/10/2014)

Historic England Research and the Historic Environment

We are the public body that looks after England's historic environment. We champion historic places, helping people understand, value and care for them.

A good understanding of the historic environment is fundamental to ensuring people appreciate and enjoy their heritage and provides the essential first step towards its effective protection.

Historic England works to improve care, understanding and public enjoyment of the historic environment. We undertake and sponsor authoritative research. We develop new approaches to interpreting and protecting heritage and provide high quality expert advice and training.

We make the results of our work available through the Historic England Research Report Series, and through journal publications and monographs. Our online magazine Historic England Research which appears twice a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities.

A full list of Research Reports, with abstracts and information on how to obtain copies, may be found on www.HistoricEngland.org.uk/researchreports

Some of these reports are interim reports, making the results of specialist investigations available in advance of full publication. They are not usually subject to external refereeing, and their conclusions may sometimes have to be modified in the light of information not available at the time of the investigation.

Where no final project report is available, you should consult the author before citing these reports in any publication. Opinions expressed in these reports are those of the author(s) and are not necessarily those of Historic England.

The Research Reports' database replaces the former:

Ancient Monuments Laboratory (AML) Reports Series
The Centre for Archaeology (CfA) Reports Series
The Archaeological Investigation Report Series and
The Architectural Investigation Reports Series.

ISSN 2059-4453 (Online)